GEOLOGICAL SURVEY OF OHIO

FOURTH SERIES, BULLETIN 47

GEOLOGY OF HOLMES COUNTY

By

GEORGE W. WHITE

GAS AND OIL

By

RAYMOND E. LAMBORN

COLUMBUS

1949

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JOHN H. MELVIN, State Geologist

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INTRODUCTION

LOCATION AND AREA

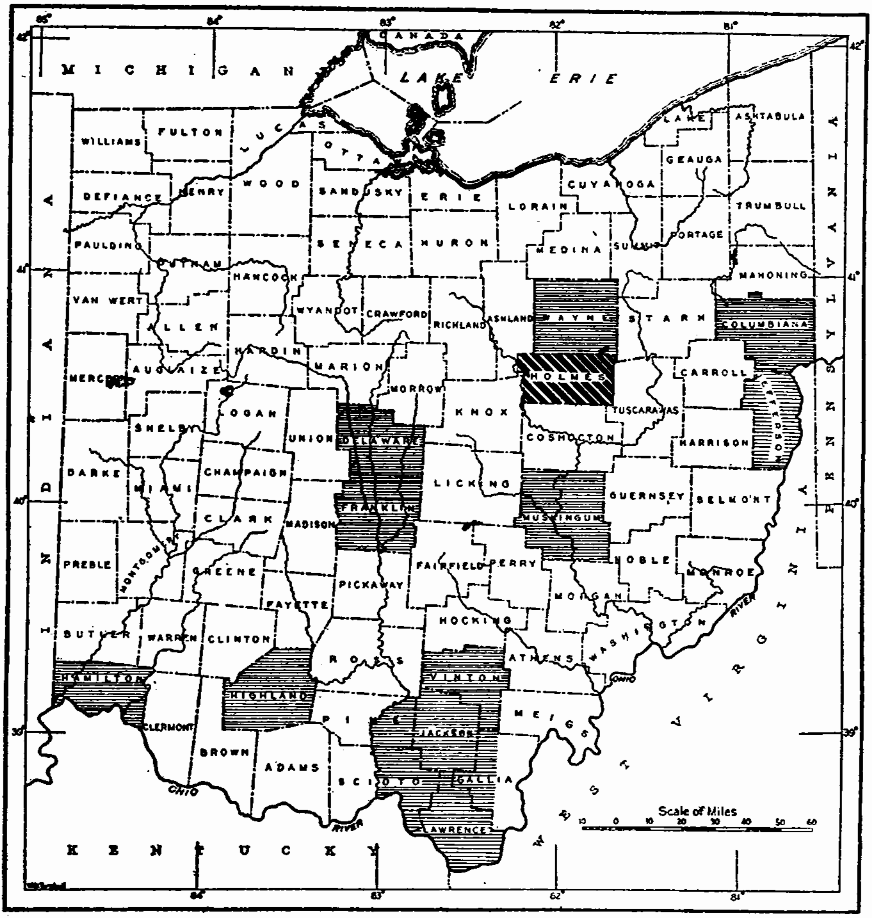
Holmes County is located in northeastern central Ohio. Its northern boundary is about 65 miles south of Lake Erie and its eastern boundary the same distance west of the Ohio River. The county is almost rectangular in form, with its greatest east-west distance 30½ miles and north-south distance 15½ miles. Its area is 423.18 square miles.[1] It is subdivided into 14 townships of unequal area. The county is bounded on the north by Wayne County, on the east by Stark and Tuscarawas, on the south by Coshocton, and on the west by Knox and Ashland. Its northern boundary is approximately 40° 40′ north latitude; its eastern boundary 81° 40′ west longitude. Millersburg, the county seat, is in the center of the county, 40° 33′ N and 81° 55′ W.

The area of the county is shown on parts of six topographic maps of the United States Geological Survey: Navarre, Millersburg, Loudonville, Newcomerstown, Coshocton, and Brinkhaven. The parts of these covering Holmes County have been used as the base for the geologic map accompanying this bulletin.

Holmes County is an agricultural county. It has no cities, but includes several thriving villages — Millersburg, the county seat and the largest, Killbuck, Holmesville, Glenmont, Nashville, Big Prairie, and Lakeville. Many smaller villages, such as Berlin, Winesburg, Walnut Creek, Mt. Hope, Benton, Charm, Farmerstown, and Stillwell are included in the county. Mineral resources of coal, clay, limestone, and sandstone are widely distributed over the county but have been extracted only in a local way, except for a few medium-sized coal operations, a major sandstone operation, and a clay operation now inactive.

The county is traversed from north to south and southwest by the Cleveland, Akron & Columbus line of the Pennsylvania Railroad. The Baltimore & Ohio Railway branch from Wooster to Millersburg has now been abandoned, as has the Walhonding branch of the Pennsylvania Railroad in the Mohican River Valley in the western part of the county.

[1] Sherman, C. E., Ohio Cooperative Topographic Survey, Vol. 4, p. 49, 1933.



Map I. Shows the location of Holmes County in the State and of other counties for which bulletins have been issued by the Geological Survey of Ohio.

PART I — PHYSIOGRAPHY

TOPOGRAPHY

Holmes County lies in the Appalachian Plateau physiographic province, but the northern half of the county is in the Glaciated Plateau section and the southern half in the Unglaciated Plateau section.[1]

The northern part (about the northern third) of Holmes County is a rolling upland having a local relief on the upland surface of from 100 to 200 feet, but cut by valleys having floors from 200 to 300 feet below the upland surface. The bedrock is generally, but not always, concealed by a mantle of glacial drift, generally till on the uplands and upper valley slopes, but in many places gravel on the lower slopes.

The southern part (a little more than a third) of the county is an unglaciated plateau dissected to the stage of early to middle maturity in the erosion cycle. Although its elevation is no greater than the northern part, it is far rougher. Narrow areas of rolling upland remain on the divides and the valley floors are from a small fraction to over half a mile in width. The major part of this region is in slope. The surface material is residual and has been derived from the weathering of local bedrock. Bedrock crops out in ravines and road cuts, but, except for certain massive sandstones, not commonly elsewhere.

An east-west strip across the center of the county, ranging in width from about 1 mile in Paint Township in the eastern part to 3 or 4 miles in the western part, forms a transition between the rugged unglaciated part and the much more rounded and smoother northern part. The southern margin is, of course, the glacial boundary. The transition belt is that part which has been more thinly covered by marginal drift. In it, bedrock crops out more commonly than farther north. It has a "masked erosional topography."

The broad valley of Killbuck Creek, crossing the county from north to south, is a conspicuous topographic feature. Its flat valley bottom, half a mile in width, lies from 250 to 400 feet below the upland surface. The valleys of major tributaries to Killbuck Creek are likewise prominent features. From north to south these are the valleys of Salt, Paint, Martins, Shrimplin, Black, Wolf, and Doughty creeks. In the northwestern part of the county the deep valley of the Mohican River is a major topographic feature as is that of its tributary, Lake Fork. These two valleys are narrower than that of Killbuck Creek. In the eastern part of the county the

[1] Fenneman, N. M., Physiography of Eastern United States, p. 283 and pl. 2, New York, 1938.

valleys of tributaries to Sugar Creek, which lies east of Holmes County, are conspicuous. From north to south these are the valleys of Middle Fork, Indian Trail Creek, Walnut Creek, and South Fork.

A conspicuous feature of northern Washington Township, in the northwestern part of the county, is the valley which enters the county at Loudonville and trends east-northeast to Big Prairie, where it passes into Wayne County. This valley is more than a mile in width, being wider than the valleys of Mohican River or Lake Fork. No stream follows this valley, although Lake Fork flows directly across it. It is an ancient valley from which its stream was diverted by glaciation, and will be discussed below.

The lowest elevation in the county is approximately 790 feet above sea level where Killbuck Creek leaves the county. The highest elevation of approximately 1,410 feet is found in northeastern Knox Township at the top of the high knob on the divide 300 yards east of the north-south road and 1½ miles south-southeast of Nashville. (The second highest point is the elongate knob 1,390 feet in elevation 2 miles west of Nashville, on the Washington-Knox township line.) The total relief is thus about 620 feet. The relief, however, over distances of 1 or 2 miles is not usually more than 200 to 300 feet, and in many places is less than that. The steepest slopes are along the valley of Black Creek near Glenmont, and along the Mohican Valley, where the relief in places is 300 feet in less than half a mile.

Most of the upland in the county lies between 1,200 to 1,300 feet. Much of it is about 1,240 feet, with knobs rising above the general surface. The largest areas above 1,300 feet are in the vicinity of Nashville.

The concordant ridge summits, generally at an elevation of about 1,240 feet, are interpreted as remnants of an erosional plain, or peneplain, which has been traced over eastern Ohio and through many states of the Appalachian Plateau.[1] This erosional plain is identified as Harrisburg,[2] which is the equivalent of Lexington (Worthington).[3]

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[1] Cole, W. S., Nomenclature and Correlation of Appalachian Erosion Surfaces: Jour. Geol., Vol. 49, pp. 129-148, 1941; Identification of Erosion Surfaces in Eastern and Southern Ohio: *ibid.*, Vol. 42, pp. 285-294, 1934.

Shaffer, P. R., Correlation of the Erosion Surfaces of the Southern Appalachians: Jour. Geol., Vol. 55, pp. 343-352, 1947.

Stout, W., and Lamb, G. F., Physiographic Features of Southeastern Ohio: Ohio Jour. Sci., Vol. 38, pp. 49-83, 1938.

Stout, W., Ver Steeg, K., and Lamb, G. F., Geology of Water in Ohio: Geol. Survey Ohio Bull. 44, 1943, bibliography pp. 98-106.

Ver Steeg, K., Correlation of Appalachian Peneplanes: Pan. Amer. Geol., Vol. 73, pp. 203-210, 1940; Erosion Surfaces of Eastern Ohio: *ibid.*, Vol. 55, pp. 93-102, 181-192, 1931; Some Features of Appalachian Peneplanes: *ibid.*, Vol. 53, pp. 359-364, Vol. 54, pp. 17-28, 1930.

[2] Ver Steeg, K., *op. cit.*, 1930, pp. 22-24. The profiles shown on plate 3 include Loudonville, Millersburg, and Navarre quadrangles and cross Holmes County.

[3] In earlier papers, Cole, *op. cit.*, 1934, uses the term "Lexington" but this is correlated by him with the Harrisburg of eastern Pennsylvania, *op. cit.*, 1941, p. 134.

DRAINAGE

Holmes County is entirely within the Muskingum River drainage basin from which the water flows to the Ohio River and thence to the Mississippi River and the Gulf of Mexico. The drainage of most of the county is to Killbuck Creek and its tributaries. The eastern part of the county is drained by tributaries of Sugar Creek, which lies east of Holmes County. A small part of the western portion of the county is drained by the Mohican River or its major tributary, Lake Fork. As the streams are shown on the map accompanying this bulletin, detailed descriptions of their locations and courses are not necessary.

EARLIER DRAINAGE SYSTEMS

The present drainage of the county shows many features which are not characteristic of normal valley systems. Striking examples are the abandoned valley from Loudonville to Big Prairie and the course of Doughty Creek from a wide valley in Berlin Township, through a very narrow gorge at Troyers Mill, to a wide valley again southwest of Becks Mills in Mechanic Township. Killbuck Creek is flowing far above the rock floor of its valley. Elsewhere in Ohio similar anomalous drainage features are well known, and those in Holmes County are part of the whole pattern of drainage changes known to have taken place in the region. Since the changes are regional and have been brought about by regional controls, the area of a single county is too small a unit for extensive analysis of the problem. An analysis has been made for north central Ohio[1] and the drainage changes within Holmes County are here only briefly described, the interpretation being based on this regional analysis.

The oldest drainage system was developed in the long period before the earliest ice sheet invaded Ohio. Early in the Pleistocene, or ice age, an ice sheet which did not advance into the region did reach far enough into the State to dam north- and northwest-flowing streams and cause some of them to take new courses. These streams cut deep valleys, at places 200 to 300 feet below the levels of former valleys. Their rock floors are now concealed by 200 feet or more of later deposits. The valleys are called "Deep Stage." Certain Deep Stage streams were forced to shift their courses by the advance of the Illinoian ice sheet into the region, thus producing a new drainage system, the "post-Illinoian." The advance of the latest ice sheet, the Wisconsin, caused other derangements, and the present system came into existence. These systems are shown on Maps II and III.

[1] White, G. W., Drainage History of North Central Ohio: Ohio Jour. Sci., Vol. 34, pp. 365-382, 1934.

PRE-PLEISTOCENE DRAINAGE

The courses of the pre-Pleistocene streams in this region are largely hypothetical. The fact that a valley is now mature, or is too wide or too deep for the stream it carries, or is abandoned entirely, does not necessarily indicate that it is preglacial in age. It may have been formed during an interglacial stage and be only earlier than the glacial advance that caused the diversion. The basic postulate in reconstructing the pre-Pleistocene drainage is that the streams had become adjusted during the long erosion interval of Mesozoic and Tertiary times and that at the end of the Pliocene the direction of the flow of the streams was the same as that of the slope of the land or, in other words, that the streams were flowing from high land to low land. Therefore, to reconstruct the preglacial stream systems, it is necessary to determine the location of the major and branch divides. It cannot be doubted that streams drained the basins bounded by these divides.

The major pre-Pleistocene divide, as shown on Map II, extends eastward from central Morrow County, across southern Richland County, and along the north line of Knox County to Holmes County, and thence in a general east-southeast direction to northern Mechanic Township of Holmes County, where it turns southeast and enters Coshocton County at New Bedford, thence passing into Tuscarawas County just south of Baltic. This tracing in the eastern part of the region agrees with that suggested by Coffey.[1] From the major east-west divide other divides extended north and south, thus delimiting the headwaters of drainage basins. One branch divide ran north to southeastern Wayne County. Another had a north-south course in Ashland County east of the present Black Fork, but its connection with the major divide to the south is now obscure because of severe dissection by later streams. A very important divide, still well preserved, extended south from the major divide, across southwestern Holmes County and western Coshocton County, about 2 miles east of the Knox County line.

These divides mark out the boundaries of the headwaters of certain basins and, on this basis, hypothetical pre-Pleistocene streams are drawn as shown on Map II. This region, then, had a somewhat radial system of drainage, with streams flowing outward from the highest parts of the Allegheny Plateau[2].

This system of drainage is probably correlative with the Parker strath system in southern Ohio which was tributary to the Teays River. It is believed that the valley bottom of the Teays was above the present drainage

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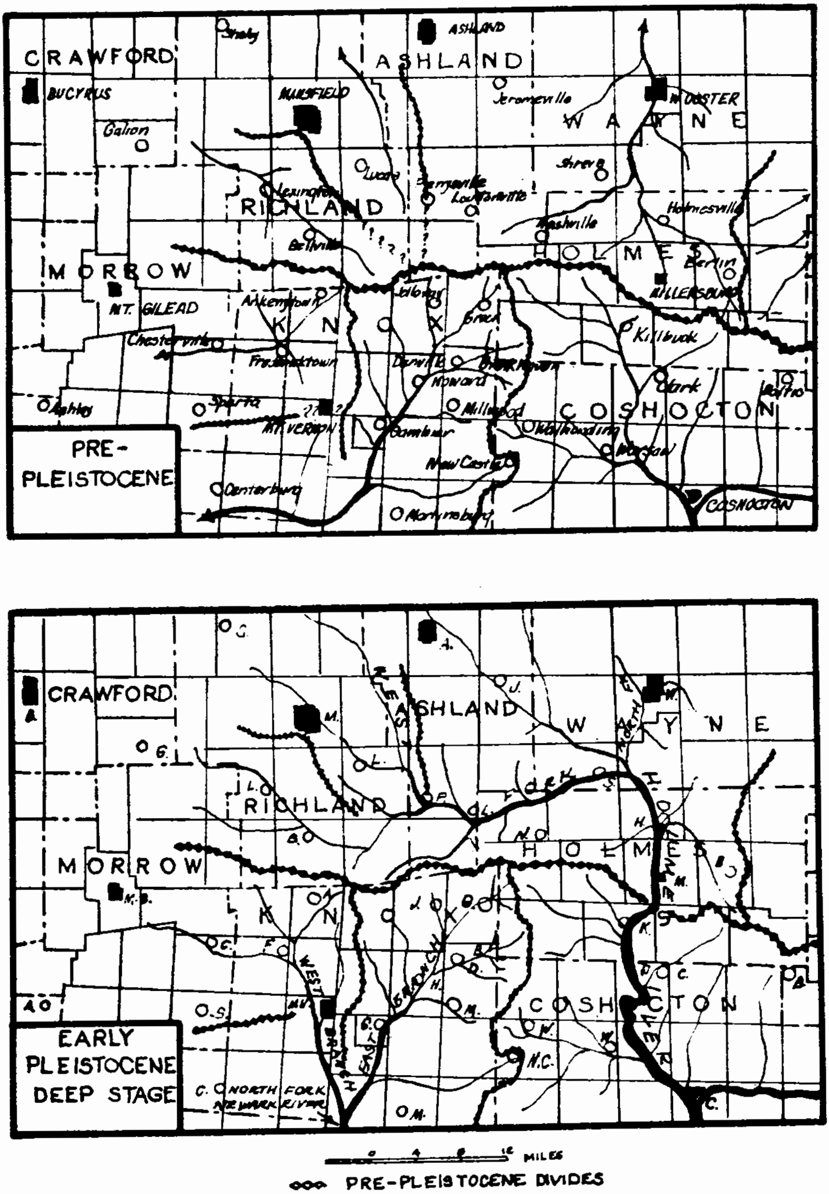
[1] Coffey, G. N., Preglacial, Interglacial and Postglacial Changes of Drainage in Northeastern Ohio with Special Reference to the Upper Muskingum Drainage Basin: Ohio Jour. Sci., Vol. 30, pp. 373-384, 1930.

[2] Ver Steeg rightly concluded (Drainage Changes in the Vicinity of Wooster, Ohio: Ohio Jour. Sci., Vol. 30, pp. 309-314, 1930) that no *deep* valley leads northward through Wayne County, but the present writer believes that a *high level* (Parker strath) valley must have drained northward since the divides west and south of Wayne County and in the eastern part of the county enclose a basin whose only natural outlet is northward.



Map II. Showing Pre-Pleistocene (upper map) and Early Pleistocene (lower map) streams and divides.

and that the streams in tributary valleys flowed at levels well above the present streams. As the preglacial streams in Holmes County were all near main divides, their positions were probably still farther above the present water courses. On this basis, the deep valleys in Holmes County are not preglacial. These shallow ancient preglacial valleys have been so cut down, or transected, and so modified by drift in the glaciated portion that often they cannot be located precisely. It must be emphasized that the pre-Pleistocene streams indicated on Map II are largely hypothetical, especially in the glaciated part of the area, and are so mapped because each basin, marked by divides still preserved, must have been drained by a stream flowing from that basin. In the unglaciated part of the region, streams of later age have had their courses fixed by preglacial valleys, but because of later stream work it has not been possible to identify the preglacial valley floors.

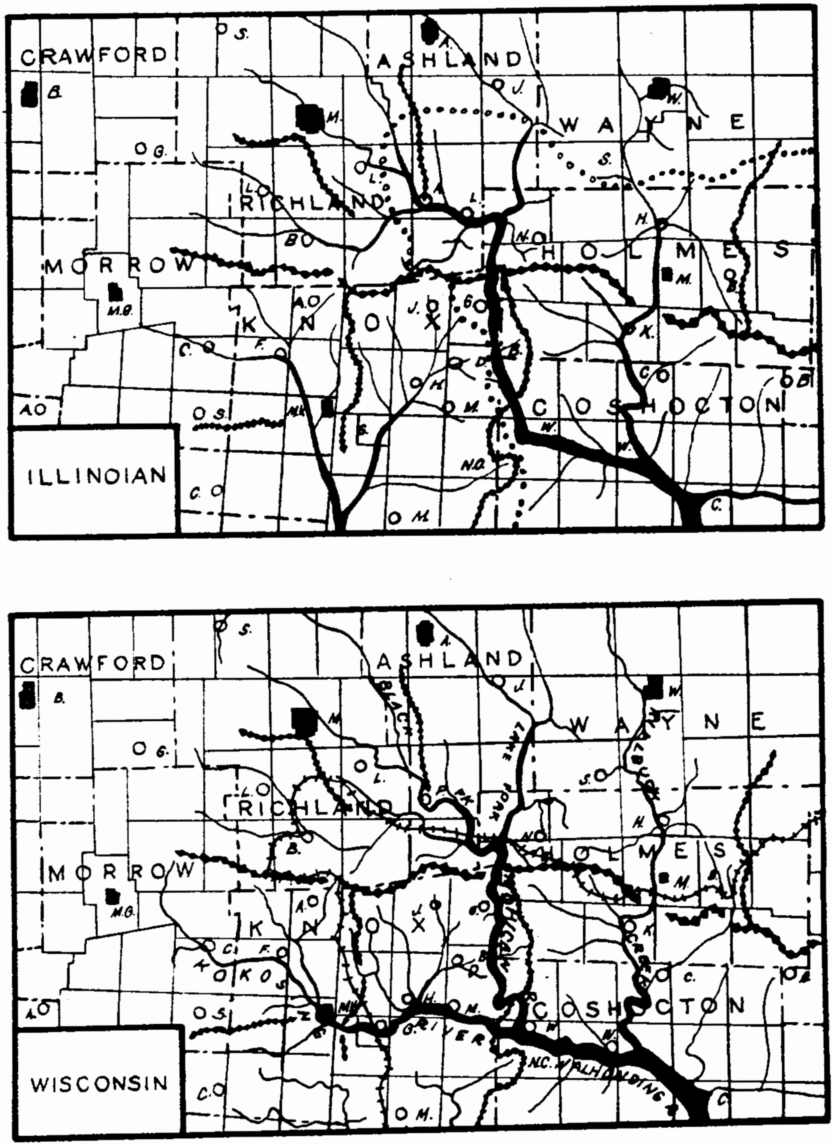
EARLY PLEISTOCENE DIVERSIONS—DEEP STAGE

The preglacial streams which flowed north or west from the region were partly or wholly blocked in early Pleistocene time. New systems of streams were developed which flowed southeast into the Allegheny Plateau and across divides to join streams which flowed south, eventually emptying into the newly formed Ohio River. The collected waters broke through the main divide at one place, and the col near Killbuck village is the only early Pleistocene col across the main divide in the area. Such diversions took place long before the Illinoian glacial stage. In order to explain them it is necessary to postulate that an early Pleistocene ice sheet, of which to date no other evidence has been discovered, advanced to the north and west borders of the Allegheny Plateau. This ice sheet may have been either the Nebraskan or the Kansan of the Mississippi Valley succession.

Northward and westward flowing streams were ponded, water broke over the lowest places in divides, and stream courses were established which persisted after the ice withdrew. A long interval of time elapsed between the retreat of this early Pleistocene ice sheet and the oncoming of the Illinoian ice sheet, during which the new streams widened and deepened their valleys. Sufficient time was available for some of the large streams to integrate partially their attendant systems. Valleys were widened to a state of maturity and deepened 150 to 300 feet below the present stream levels.[1]

A Deep Stage stream valley which drained almost all the northern part of this area cuts across northwestern and central Holmes County. It was brought into existence by pre-Illinoian ice at the north border of the

[1] Cf. Ver Steeg, K., The Thickness of the Glacial Deposits in Ohio: Science, Vol. 78, p. 459, 1933; and The Buried Topography of North-Central Ohio and its Origin: Jour. Geol. Vol. 42, pp. 602-620, 1934.



• • • • KNOWN ILLINOIAN BOUNDARY ∘ •• POSTULATED ILLINOIAN BOUNDARY ++ WISCONSIN BOUNDARY

Map III. Showing Illinoian (upper map) and Wisconsin (lower map) streams.

Allegheny Plateau. The ponded waters escaped southward through the lowest place in the main divide, a col between Millersburg and Killbuck. Black Fork now follows the old valley from Perrysville to Loudonville, but from Loudonville eastward past Shreve this Deep Stage valley is now abandoned. The Deep Stage stream flowed southward from a point east of Shreve across Holmes County in the valley now occupied by Killbuck Creek through a col, now almost 1 mile wide, in the pre-Pleistocene divide between Millersburg and the village of Killbuck, about 1 mile northeast of the latter. South of the col the river entered a pre-Pleistocene drainage system unaffected by glaciation and flowed south to Coshocton, where it joined the ancient (Deep Stage) Newark River.

ILLINOIAN DIVERSIONS

The Illinoian ice front lay from 1 to 5 miles west of the present Mohican River in northeastern Knox County and continued just east of south across Newcastle and Perry townships of Coshocton County, from 1 to 8 miles west of a preglacial north-south divide.[1] The ice dammed the headwaters of the westward and southwestward flowing tributaries to the Deep Stage North Fork of the Newark River and caused the water to flow south across westward-extending spurs of the north-south divide, from one headwater basin to the next, as far as southwestern Tiverton Township, Coshocton County. Here a low place in the north-south divide allowed the water to break over to the southeast and enter the valley of the Walhonding River, which then, as now, flowed east-southeast to Coshocton and joined the Tuscarawas River.

Lake Fork now flows from the junction of Jerome and Muddy forks southward across southeastern Ashland County, crosses the Deep Stage valley in northwestern Holmes County, and thence flows southwest across the southern boundary of Washington Township to the Mohican River. The valleys of its tributaries, Jerome and Muddy forks, are 2 to 3 miles wide and are certainly pre-Illinoian (Deep Stage), but the valley of Lake Fork is only one-fourth to one-half mile wide, except where it crosses the ancient valley. On this basis Lake Fork Valley is believed not to be a Deep Stage valley. Its width is, however, greater than that of the valley of Clear Fork in Ashland County, which is canyon-like and which is definitely Wisconsin in age. On these bases Lake Fork Valley is believed to have come into existence with the Illinoian ice stage. To block the mouth of the Deep Stage river in southern Wayne County, and to divert the Deep Stage streams of Jerome Fork and Muddy Fork valleys from their southeasterly courses, an obstruction was necessary. It is therefore postulated that a lobe of the Illinoian glacier east of the Scioto lobe extended as far south as Shreve, but not as far as did the later Wisconsin ice, for no Illinoian drift

[1] White, G. W., Illinoian Drift Region of Northeast Central Ohio: Ohio Jour. Sci., Vol. 37, pp. 1-19, 1937.

has been discovered in this region south of the Wisconsin boundary. The location of this postulated portion of the Illinoian boundary is shown on Map III.

WISCONSIN DIVERSIONS

The Wisconsin glacier advanced to the limits shown on Map III and on the map of glacial deposits of the county. The glacier's presence caused several major diversions and many minor changes. When the Wisconsin ice had finally disappeared the present day drainage system was established.

The headwaters of Martins Creek in southern Berlin Township, ponded by the Wisconsin glacier, broke through the main east-west divide in northeastern Mechanic Township, entered Doughty Creek, and flowed southwestward to join Killbuck Creek in northern Coshocton County. The course of the stream through the divide is a narrow gorge 2 miles in length called "Troyers Hollow." Doughty Creek and Martins Creek now rise in an area of morainic topography in central and northern Berlin Township, Martins Creek flowing north from the southeastern part of the township and Doughty Creek flowing south from the northern part, their courses being only from 1 to 2 miles apart for a distance of 4 miles.

Sigafoos Run, at the Washington-Knox township line, underwent diversion of its lower course, which in pre-Wisconsin time was north from Knox Township to the ancient valley in central Washington Township. The Wisconsin ice advanced as far as the southern limit of Washington Township, blocking the northward flowing stream and forcing it to flow westward, where it cut a narrow gorge for a mile along the front of the ice to the present Mohican River. Black Fork, which flows through Loudonville, about a mile west of Holmes County, was also deranged by the Wisconsin ice, as shown on Map III. It is described elsewhere.[1]

GLACIAL DEPOSITS

The material overlying the bedrock in the northern half of Holmes County is of glacial origin and consists of boulder clay (till) and stratified gravel and sand. The southern part of the county has no such deposits, except along some of the streams where sand and gravel of glacial origin has been carried from the north.

The glacial deposits of Holmes County have been described in a general way by Wright[2] and by Leverett.[3] The present writer has described the deposits, as well as those in other counties, and the following discussion

[1] White, G. W., Drainage History of North Central Ohio: *op. cit.*, pp. 378-379.

[2] Wright, G. F., The Glacial Boundary in Ohio, Indiana, and Kentucky: Western Reserve Hist. Soc. Tract No. 60, pp. 193-268; [in Ohio] Geol. Survey Ohio, Vol. V, pp. 750-772, 1884; U. S. Geol. Survey Bull. 58, 1890.

[3] Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: U. S. Geol. Survey Mon., 41, 1902.

of Holmes County glacial features is in part adapted from his earlier publications.[1]

The Glacial epoch (Pleistocene) is the last major division of geologic time. It began about 1,000,000 years ago and came to an end (in Ohio) about 40,000 years ago. During this epoch a series of four major ice invasions took place in northern United States. Long interglacial stages of moderate temperature, similar in a general way to present climatic conditions, separated the stages of lowered temperature and ice sheet formation and advance. These glacial and interglacial stages are as follows:

Postglacial time
Wisconsin glacial stage (last)
Sangamon interglacial
Illinoian glacial stage
Yarmouth interglacial
Kansan glacial stage
Aftonian interglacial
Nebraskan glacial stage (earliest)

Drift of the first two glacial stages has not been recognized in Ohio, but indirect evidence of early Pleistocene drainage changes already described indicates that one of the early ice sheets reached northern and northweastern Ohio. Illinoian drift is present beyond the Wisconsin drift in nearby counties—Stark,[2] Ashland, Richland, and Knox,[3]—but there is none in Holmes County beyond the margin of Wisconsin drift.

The Wisconsin ice sheet advanced into Ohio in a series of lobes. The Grand River lobe occupied the Grand River basin in eastern Ohio and the margin of its drift may be traced from the Pennsylvania-Ohio line to Canton.[4] The Killbuck lobe advanced into the general region of the Killbuck basin and adjacent territory has been given this name from its location.[5] The margin of its drift extends from Canton to a point west of Mansfield. The drift of Holmes County belongs to this lobe. The

[1] White, G. W., Varved Clay in Holmes County, Ohio: Science, Vol. 74, pp. 441-442, 1931.

Glaciation of Northwestern Holmes County, Ohio: Ohio Jour. Sci., Vol. 31, pp. 429-453, 1931.

An Area of Glacier Stagnation in Ohio: Jour. Geol., Vol. 40, pp. 238-258, 1932.

The Pleistocene Geology of the Region of the Reentrant angle in the Glacial Boundary in North Central Ohio: Abstracts of Doctor's Dissertations, No. 13, Ohio State University, pp. 282-293, 1934.

Illinoian Drift Region of Northeast Central Ohio: Ohio Jour. Sci., Vol. 37, pp. 1-19, 1937.

Illinoian Drift in Eastern Ohio: Am. Jour. Sci., Vol. 237, pp. 161-174, 1939.

[2] White, G. W., in Schaefer, E. J., White, G. W., and Van Tuyl, D. W., The Ground Water Resources of the Glacial Deposits in the Vicinity of Canton, Ohio: Ohio Water Resources Board Bull. 3 p. 11, 1946.

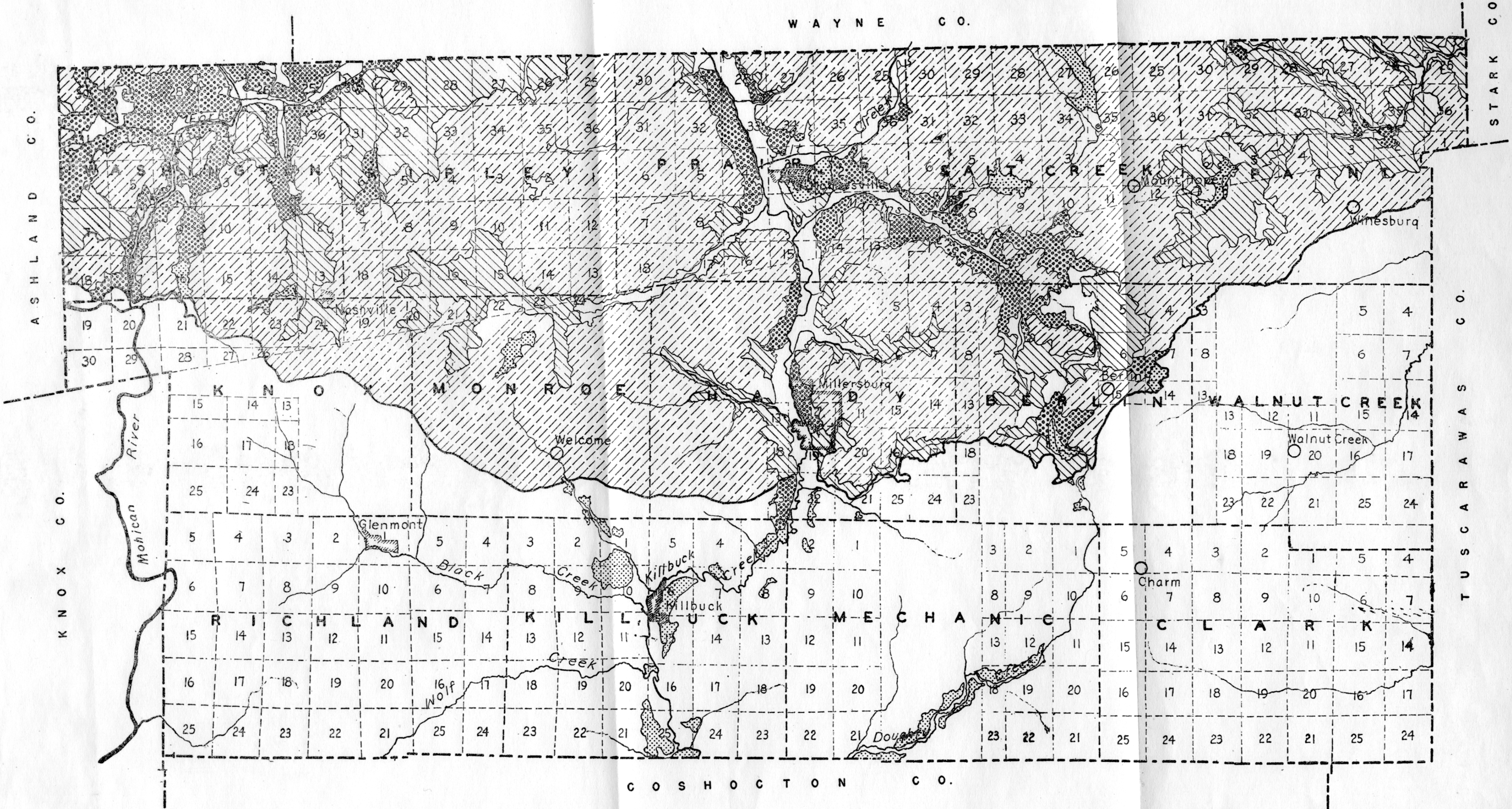
[3] White, G. W., *op. cit.*, 1934, 1937, 1939.

[4] White, G. W., Illinoian and Wisconsin Drift of the Grand River Lobe in Eastern Ohio (abstract): Bull. Geol. Soc. Am., Vol. 53; p. 1813, 1942.

Leverett, F., *op. cit.*, p. 438.

[5] White, *op. cit.*, p. 286, 1934.

MAP IV



MAP OF
GLACIAL DEPOSITS
OF
HOLMES COUNTY
by GEORGE W. WHITE

Miles

STATE OF OHIO
DEPARTMENT OF PUBLIC WORKS
GEOLOGICAL SURVEY OF OHIO
JOHN H. MELVIN, STATE GEOLOGIST,
COLUMBUS
1948

LEGEND

FLOOD PLAINS AND ICE BLOCK DEPRESSIONS (Within glaciated area)

AREAS OF GROUND MORAINE TOPOGRAPHY (Till)

KAMES AND KAME TERRACES (Gravel)

AREAS OF MORAINIC TOPOGRAPHY (Till)

VALLEY TRAINS (Sand and gravel) (Includes small areas of lake sands in Paint, Salt Creek, and Monroe Twps.)

Wisconsin ice sheet of central Ohio made up the Scioto lobe[1]; that of western Ohio, the Miami lobe.[2]

Four major advances of the Wisconsin ice sheet, separated by considerable retreats, are recognized in the Mississippi Valley region. The earliest of these, the "Iowan" substage, is probably not represented in Ohio; and the latest, the "Mankato," appears not to have reached as far south as Ohio. The Wisconsin drift of Ohio is probably of the second and third (Tazewell and Cary) of the Wisconsin ice advances, but as yet these have not been satisfactorily separated in the State. The Wisconsin drift of Holmes County is all of one stage, most probably the third. It is here referred to only as Wisconsin drift.

GLACIAL BOUNDARY

The Wisconsin ice sheet advanced in eastern Ohio to about the latitude 40°45′. The southern border of the Grand River lobe entered Ohio from Pennsylvania, about 10 miles north of the Ohio River, and extended westward through central Columbiana County, past Lisbon and through central Stark County to Canton, where it joined the east edge of the Killbuck lobe.[3] The border of the Killbuck lobe extended southwestward from Canton across southwestern Stark County, the extreme northwestern corner of Tuscarawas County, and northeastern Holmes County to near Berlin. Here the border swung westward in a broad curve with the most southern point south of Millersburg and continued north of west across western Holmes County, entering Ashland County 2 miles south of Loudonville. The ice border continued this northwest course across southern Ashland County and southeastern Richland County to a point 5 miles south of Mansfield, where it joined the east side of the Scioto lobe.

The glacial boundary in Holmes County is, at most places, not marked by a terminal moraine. Topography and deposits which are definitely of morainic character are found no closer than 1 or 2 miles to the boundary except in some valleys. Only a veneer of till is present on the hilltops and ridges within half a mile, and in some places within a mile of the boundary. Approaching the boundary from the north, one passes from a thick mantle of till to a thin mantle, thence to discontinuous drift, and thence into a region where only a few foreign boulders are present. The farthest southerly extent of these foreign boulders has been taken as the limit of the Wisconsin ice advance.

The characteristics and changes of the marginal deposits are well shown along Bell Ridge which trends north-south in eastern Knox Township. From Stone School, 1½ miles southeast of Nashville, the drift is thick southward for about half a mile. From this place onward the drift

[1] Leverett, F., *op. cit.*, p. 340.
[2] *Ibid.*, p. 304.
[3] White, G. W., *op. cit.*, p. 12.

becomes thinner and, about a mile southeast of Stone School, appears to die out entirely. However, igneous boulders up to 1 to 2 feet in diameter are present for three-eighths of a mile farther south. The boulders, nowhere very abundant, become fewer and fewer until, a little more than 1½ miles south-southeast of Stone School, they die out completely. The glacial boundary was mapped at the position where the last foreign boulders were seen along the ridge top.

The glacial boundary enters Holmes County from the east 1 mile southwest of where Stark, Tuscarawas, and Holmes counties meet. It has here a general southwest direction which it maintains through Paint Township, passing one-half mile south of the village of Winesburg and continuing to Doughty Creek, 2 miles south of Berlin. Crossing the valley of that stream, the boundary swings in a winding course westward to Killbuck Valley 1 mile south of Millersburg, and thence due west, just south of the crest of the east-west ridge which was the main preglacial divide, across southwestern Hardy Township into Monroe Township. In the central southern part of Monroe Township the course bends to the northwest, and passing across western Holmes County, enters Ashland County a little less than 2 miles south of Loudonville.

The Wisconsin drift boundary enters Paint Township from Wayne Township, Tuscarawas County, 1 mile north of Indian Trail Creek, and extends west-southwest across the southeastern part of the township, passing into Walnut Creek Township 1 mile west of the village of Trail. The boundary lies from one-fourth to one-half mile south of the divide between Middle Fork and Indian Trail Creek. Across Paint Township scattered boulders are present at the boundary and thin till is present a few hundred yards inside it, but no morainic deposits are found within a mile of the boundary. The most southerly drift with morainic expression is in the valley of Middle Fork, north of Winesburg, more than a mile north of the boundary.

The boundary lies just south of the north line of Walnut Creek Township from 1 mile west of Trail westward to Sec. 3, in the northwestern corner of the township, where it turns southwest, entering Berlin Township half a mile north of Indian Trail Creek. Scattered boulders are present along the Paint-Walnut Creek township line and thin till in the northern part of Sec. 3.

The boundary enters northeastern Berlin Township in SE¼ Sec. 4 and runs southwest across Sec. 7, NW Sec. 14, and Sec. 15 to Doughty Creek at Wise School. The boundary extends northwest from Doughty Creek around the east base of the hill half a mile west of Wise School, and thence westward past Sharp School into the central part of Sec. 17, Hardy Township, at the head of Upper Sand Run. The outer border of the drift on the uplands is characterized by thin till and by scattered boulders, but in the two lowlands which are crossed, it is characterized by morainic deposits. Morainic knolls 10 to 20 feet high, composed of gravel and gravelly till, occupy the lowlands at the head of Indian Trail Creek, 1 mile northeast of Berlin. To the southeast, in NW Sec. 14, a gravel outwash plain about one-fourth square mile in area was deposited in front of the ice.

A well-developed end-moraine crosses Doughty Creek Valley 2 miles southwest of Berlin, making an embankment across the valley about one-half mile long and one-fourth mile wide. It rises about 60 feet above the floor of the valley. The moraine is one continuous till and gravel ridge, and is not markedly hummocky, although a few kettle holes and shallow depressions about 10 feet deep are present on the top. Some small pockets of gravel, of sufficient volume to excavate for road purposes, have been found here and there in the moraine. A small amount of outwash apparently was swept down Doughty Creek and was deposited in the valley several miles south of the glacial boundary.

The drift boundary enters southeastern Hardy Township in NE Sec. 17, extends westward for a mile on the south side of Upper Sand Run, and comes to that stream in E Sec. 16. The boundary then follows Sand Run southwest to central Sec. 21, where it turns northwest along the north valley wall to Killbuck Valley. From the head of Upper Sand Run to the junction of Sand Run with Killbuck Creek in southeastern Hardy Township, weak morainic topography exists either in the valley bottom or on the north slope. From the junction of Upper Sand Run with Sand Run to the mouth of Sand Run, till and gravel, very thin in places, veneer the north valley wall. The drift extends up to an elevation of about 900 feet in the lower course of the valley and to about 1,000 feet in the upper part of the valley. On the slope along the north side of Sand Run Valley many igneous boulders up to 3 or 4 feet in diameter are present.

The ice front crossed the valley of Killbuck Creek in N Sec. 22. Although areas of morainic topography exist on the east and west sides of the Killbuck Valley just north of the boundary, it does not appear that an end-moraine ever extended across Killbuck Valley at the glacial boundary. Morainic knolls are inconspicuous at the glacial boundary on the east side of Killbuck Valley, but a mile to the north closely aggregated drift knolls occupy a tributary valley. Morainic knolls form a north-south belt about one-half mile wide along the west side of the valley, extending from the glacial boundary to the mouth of Sapps Run. These areas of morainic topography do not seem to be erosionally separated ends of a once continuous end-moraine which blocked Killbuck Valley as Doughty Creek Valley is yet blocked. Rather, they are related to the lowlands and follow the sinuosities of the topography as do morainic areas in valleys north of the boundary, which are believed to bear no relation to a former ice front. In NW Sec. 22 and NE Sec. 23, an outwash terrace one-half mile wide heads at the south end of the morainic tract and extends downstream for more than a mile.

From Killbuck Valley the glacial boundary runs southwest for a mile, rising to the upland. Here it turns westward across the upland and passes into Monroe Township one-half mile north of the north line of Killbuck Township. The till mantle of the border belt is thin and in many places is reduced to scattered boulders across the highland of southwestern Hardy Township.

The glacial boundary enters southeastern Monroe Township half a mile north of the north line of Killbuck Township and extends westward for 3 miles to a point 1 mile southwest of the village of Welcome. It turns here to the northwest across the upland of the southwestern part of the township and passes into Knox Township 2 miles north of the north line of Richland Township. The border lies on the upland across Monroe Township, except where it crosses the valley of Shrimplin Creek, and presents no unusual features. The glacial border in the valley of Shrimplin Creek is unusual in that there are no morainic deposits either at the boundary or inside it. In fact, there are no morainic areas within 2 miles of the boundary anywhere across Monroe Township. Low terrace remnants of a valley train head at the glacial boundary in Shrimplin Creek a little more than one half mile south of Welcome and continue down the valley to Killbuck village.

The boundary enters Knox Township from Monroe Township and has a winding course in a general west-northwest direction to a point in the north central part of the township 2 miles southwest of Nashville. Here it turns to the northwest for 2 miles, coming to Sigafoos Run which it follows northward to the south line of Washington Township. The boundary across both Knox and Monroe townships lies upon the upland just south of the high divide area and shows well the type of border where the drift thins out to scattered boulders. Bell Ridge, in the eastern part of Knox Township, has been described as a type example.

The drift boundary enters Washington Township at the south line of Sec. 16 and extends west through the southern parts of secs. 16 and 17 on the north side of the narrow valley of Sigafoos Run. This stream was diverted from its former northerly course to a westward course across a divide by the Wisconsin ice. No end-moraine is evident across the abandoned valley of this stream in S Sec. 16, but outwash gravel covers the valley bottom and extends southward into Knox Township.

From the junction of Sigafoos Run with the Mohican River the boundary crosses the mouth of Lake Fork and extends westward across the southern parts of secs. 17 and 18, passing into Hanover Township, Ashland County, one-half mile north of the Mohican River. Extensive outwash deposits have been laid down at the mouth of Lake Fork in the depression connected with Lake Fork Valley in W Sec. 17 and E Sec. 18.

CHARACTER OF TILL

The glacial deposits, or drift, in Holmes County consists of boulder clay or till deposited directly by the ice, and of outwash material, generally sand and gravel, laid down by water flowing from melting ice.

The unoxidized, unleached, fresh Wisconsin till is a bluish gray, pebbly clay of a somewhat silty character. The unaltered till is, where moist, dark gray blue, but, where dry, light blue gray. It is strongly calcareous and effervesces freely with dilute hydrochloric acid. The till is composed of an aggregation of rock fragments varying in size from rock flour to boulders. Pebbles and cobbles are common, but boulders are rare. No boulders larger than 6 feet in greatest diameter were seen.

The till is composed of rock fragments transported varying distances. Igneous and metamorphic rock particles from the Canadian shield are common. Limestone pebbles from the Erie basin are abundant and Mississippian and Pennsylvanian sandstone and shale pebbles from the immediate area make up a large proportion of the fragments.

The upper part of the till is at all places altered in some way by agencies of weathering. As a basis for discussion of the alteration, an average section is given:

	Ft.	In.
Oxidized, leached zone 3 Till: medium brown porous, leached......	4	0
Sharp contact with Zone 2		
Oxidized, unleached zone 2 Till: dark brown, calcareous........	4	0
Irregular gradation into Zone 1		
Unoxidized. unleached zone 1 Till: grayish blue, silty, calcareous, moderately hard, pebbly to cobbly; with occasional boulders; to base	0 to 50+	

The unoxidized, unleached till, Zone 1, has been described. The oxidized, unleached till, Zone 2, is brown, the exact shade varying from dark to medium, depending on the amount of moisture present. This zone has a depth of from 6 to 10 feet and grades with an uneven contact into the unoxidized blue till below, the oxidation having advanced more rapidly where the till is more porous. It is similar in texture and mineral content to the blue till of Zone 1.

The leached, oxidized Wisconsin till, Zone 3, is medium to light brown in color, the shade decreasing in intensity toward the surface. This zone is looser and more porous than Zone 2, because of the solution of limestone pebbles and finer calcareous material and because of the removal of finer rock particles by ground water. This leached zone has a thickness of from 3 to 7 feet, and rests with a sharp contact upon the oxidized, unleached zone below.

The thicknesses of zones 2 and 3 vary greatly from place to place, because the rate of oxidation is faster in more porous till and in those portions having better drainage; and because the oxidized zone is removed at the surface by erosion. On steep slopes this removal may keep pace with, or exceed, leaching.

AREAS OF MORAINIC TOPOGRAPHY

The ice-laid deposits of till are spread unevenly over the surface of the glaciated part of Holmes County. A large part has a fairly smooth surface and small to moderate thickness. Such areas, most of them on uplands, are classified as "ground moraine," and the surface as "ground moraine topography." Areas of more noticeable constructional topography in which the drift is of greater thickness are mapped and described as "areas of morainic topography."

Areas of morainic topography are irregularly distributed, occur in valleys, and do not fall into belts. They are best developed in the lower parts of valleys, but may extend up the slopes, and occasionally even exist on uplands, especially where the lowlands on either side have well-developed constructional features. It should be emphasized that these tracts trend with the valleys and lowlands, and cannot be "lined up" in any systems of end-moraines. These tracts are small, patchy, and generally do not extend high above the valley floors.

With the exception of a few small areas of terminal end-moraine along the glacial boundary, such as the ridge at Wise School in Berlin Township, and the single exception of the ridge-like small recessional end-moraine at Holmesville, the areas of morainic topography which are shown on the map of glacial deposits and which are described are not end-moraines which were made by standing or oscillation of a front of active or moving ice. They were deposited because the ice in the valley was thicker and carried more material. In the waning stage of glaciation that part of the ice sheet over Holmes County appears to have lost its motion and appears to have melted down from the top as well as back from the margin. The hilltops appeared first above the ice while ice remained in the valleys and lowlands. In the valleys the more heavily laden thicker ice, upon melting, contributed more drift which slumped down irregularly in the lowlands and along the valley sides. In the last phase of melting of the blocks which persisted longest, much of the topographically lowest drift was modified by running water and stratified deposits called "kames" or "kame terraces" were formed. These are described separately.

The surface expression of the morainic areas varies from billowy to very hummocky, with well-developed knolls and kettle holes most common in the lower parts of valleys. On the valley slopes the surface is commonly billowy rather than knobby. In some valleys the floors are occupied by kame terraces above which till, with morainic expression, rises on the valley slopes. Toward the upper limit on the valley slopes the morainic topography becomes weaker, and grades into the ground moraine of the higher valley slopes and the upland. The boundary between, although at some places quite sharp, is at most localities transitional.

The drift of the morainic areas is, in general, silty to sandy till. The till is more gravelly on the valley floors, where masses of gravel may be included. At higher elevations on the valley slopes the till is at most places devoid of gravel and is more compact.

Valley of Middle Fork, Paint Township.—Middle Fork rises at the eastern border of Salt Creek Township and flows east across Paint Township into Stark County in a flaring, mature, bedrock valley now partly filled with drift. The valley floor is from 100 to 250 feet below the upland. Thick drift deposits, aggregated in knolls 10 to 30 feet high with a few intervening undrained depressions, exist in the lower portions of the valleys of Middle Fork and its tributaries.

The tract of moraine in the valley in the northeastern corner of Paint Township in Sec. 25 is narrow and does not extend far up the valley sides. It has well-developed knolls of gravelly till 20 feet in height and a few kettle holes. Hummocky topography exists in the tributary valley in Sec. 26 and NE Sec. 27, and extends across the north line of the township into Sec. 22 of Paint Township, Wayne County.

A wider belt of well-developed knolls fills the main valleys from Bidler School in NE Sec. 35 southwest to the central part of the township. In the central part of the valley the knolls are well developed and consist of more gravelly till than the billows higher up the valley sides. Small areas of kames exist within the morainic area at the mouth of Crabapple Creek and one-half mile east along the line between secs. 35 and 2.

The lower valley sides of Crabapple Creek, from its mouth in central Paint Township northwest to the headwater tributaries in Wayne County, are covered with drift having a billowy expression. Some of the knobs in NE Sec. 29, just south of the county line, consist of poorly sorted gravel and are mapped as kames.

In the central part of Paint Township the valley of Middle Fork bifurcates. A narrower, shorter branch extends westward to the west line of the township and the main part of the valley widens into a broad lowland in southwestern Paint Township. The narrower, shorter branch valley contains, in its lower part, till with an undulating to billowy surface which grades into the smoother ground moraine about half way up the valley sides.

The valley of the main branch widens into a lowland 2 miles wide and 3 miles long, which extends southwestward into the margin of Salt Creek Township. Drift knolls 10 to 30 feet high are best developed in the central part of the lowland. Toward the border of the lowland the topography becomes less billowy and at an elevation of about 1,200 feet grades into the gently undulating surface of the ground moraine which mantles the upland. An elongate swampy depression exists in the southeastern portion of this area 1 mile northeast of Easley School. This depression drains south to Indian Trail Creek, south of the glacial boundary, through a narrow gorge which was cut by glacial waters.

Headwaters of Martins and Doughty Creeks.—Martins Creek is formed by a number of small streams which rise in a morainic area in western Berlin Township, Holmes County, and unite to flow northwest across southwestern Salt Creek Township. Doughty Creek rises in the same morainic area in northern Berlin Township and flows southward across the glacial boundary. The area of morainic topography under consideration is located in a single valley, which formerly drained northwest. The area is now drained by two streams flowing in opposite directions.

The area begins at the glacial boundary in southern Berlin Township and extends northward 3 to 4 miles, giving place to a kame area 1 mile south of the north line of Berlin Township. South of Boyd School an eastward prong passes off which broadens out into an area of 2 to 3 square miles in northeastern Berlin Township. The ridge-like end-moraine across Doughty Creek at the glacial boundary near Wise School has been described. For 2 miles north of the boundary the valley sides are thickly veneered with drift aggregated in low knolls or billows. The center of the valley is a swampy depression. The outer boundary of this tract is very irregular, following approximately a line having an altitude of 1,100 feet. The drift of the lower, central part of this tract ranges from gravelly till to poorly sorted, cobbly gravel, aggregated in low knolls. The drift of the outer part of the tract is boulder clay in which are included occasional small masses of gravelly till. East of Buena Vista School the lowland is partly filled with well-developed knolls of gravelly till, which grade northward into a kame area. Two large elongate kettle holes exist in this tract, one northeast and one southeast of the school.

The eastward extension of the tract of morainic topography north of Berlin covers most of secs. 5 and 6 and small parts of the sections to the north and west. On the southeast it reaches the glacial boundary in NE Sec. 15 and SW Sec. 7, where kame-like knolls are present. The morainic surface of this area rises from an elevation of approximately 1,100 feet on the west to an elevation of about 1,200 feet against the upland to the east. Well-developed knolls of till with included gravel masses rise 20 to 40 feet above the lowland in NW Sec. 6 and SW Sec. 5 along the border of the Plains. Higher up on the slopes in NE Sec. 6 and in most of Sec. 5 the till is more clayey and the surface is billowy, rather than hummocky, grading into the undulating ground moraine of the upland. The kame area along Martins Creek Valley to the northwest will be described separately.

Killbuck Valley—Killbuck Creek flows from north to south across the glaciated part of central Holmes County. Areas of morainic topography exist at various places along the sides of its valley and extend up some of the tributary valleys. The drift knolls at the glacial boundary in the valley of Sand Run and in Killbuck Valley have been described.

North of the boundary, the belt of morainic topography extends along the west side of Killbuck Valley and northwest to the head of Sapps Run, a distance of about 3 miles. This tract in the valley of Sapps Run is narrow and is confined to the center of the valley. The billowy character of the lower slopes changes to the smoother surface of the ground moraine at elevations 40 to 60 feet above the valley floor. In the smaller valley the knolls are lower and weaker than in the larger Killbuck Valley to the southeast.

Morainic topography exists in the valley of a small tributary entering Killbuck Creek from the east, 1 mile north of the glacial boundary. This tract includes the southern part of Millersburg and NW Sec. 20, Hardy Township, and has drift knolls 10 to 40 feet in height with a few shallow undrained depressions between the knolls. The boundaries of this area are fairly definite because the ground moraine adjoining is so thin that bedrock outcrops are common. The Millersburg golf course is located upon the northeastern part of this tract, where the morainic surface reduces to a minimum the necessity of artificial hazards.

A small area of morainic topography, less than 1 square mile in extent, exists in the small valley tributary to Killbuck Creek 1 mile northwest of Millersburg. The topography consists of low knolls near Killbuck Valley and billowy swells on the lower valley slopes.

Morainic knolls cover the floor of the valley of Honey Run in northeastern Hardy Township and veneer the lower part of the valley slopes from its mouth eastward to its head in S Sec. 4, a distance of about 3 miles. The knolls are especially well developed in that part of the valley from Honey Run School to Sec. 6. A narrow belt of billowy topography extends northward along the Killbuck Valley slope from the mouth of Honey Run to Colliers Run and for about a mile up the valley of Colliers Run.

Holmesville Moraine—A morainic ridge of peculiar form extends almost across the Killbuck Valley in Prairie Township, south of Holmesville. This ridge lies east of Killbuck Creek. The eastern end of this moraine is located in S Sec. 2, where it emerges from the kame terrace area on the north side of Martins Creek. The ridge extends 1 mile southwest into central Sec. 10, where it bends northwest to its termination at the southwest corner of Holmesville. The ridge is one-eighth of a mile wide at its eastern end, increases to a width of three-eighths of a mile in its central portion, and decreases to one-quarter mile at its western end. It ranges from 60 to 80 feet in height.[1]

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[1] Cf. Cole, G. G., The Holmesville, Ohio, Glacial Terrace and Moraine, (abstract): Science, N. S., Vol. 47, p. 469, 1918.

The surface of the moraine is composed of low knolls and a few shallow kettle holes. The material of which it is built is mainly sandy to gravelly till. Some masses of dirty gravel are included in the till, but no large masses are known, although local contractors have prospected the ridge carefully in their search for road gravel.

This morainic ridge does not now extend entirely across the Killbuck Valley nor does it give evidence of ever having done so. There is no till ridge on the west side of Killbuck Creek which would match with the west end of the moraine. Three possible modes of origin for the ridge are here considered:

(1). The morainic ridge may have been deposited in a crevasse or open space between dead ice blocks in the valleys of Martins and Killbuck creeks and in the lowlands at Holmesville. The evidence for isolated ice masses in the valley of Martins Creek is conclusive as discussed in the section on "Kame Terraces." However, crevasse fillings consist mainly of water-sorted material, and this ridge is mainly till. It is therefore not the usual crevasse-filling type.

(2). It may have been deposited at an active ice front which stood in this location after the territory to the south had been freed of ice. A definite ice front never existed to the east or west of this moraine on the upland, but a small lobe of ice in the lowland north of the moraine may have maintained its continuity with the main ice sheet, while to the east and west the ice sheet had become disintegrated into separated masses and blocks. The absence of an outwash plain south of the moraine indicates that sufficient open space did not exist for its deposition, probably because masses of dead ice were present there.

(3). The ridge may have been deposited by live ice while dead ice remained in front. Moraines in Denmark deposited in this way have been described by Andersen.[1] Evidences in Massachusetts of ice reädvance in restricted areas while dead ice nearby remained stationary have been discovered by Brown.[2] This ridge may be an isolated Ohio example of such a deposit. Kame terrace gravel across Martins Creek immediately south of the moraine shows that dead ice existed just south of the position of the moraine at some time. The kame terrace and the moraine are distinctly separated from each other, and it seems most logical that the agent which kept them separated was dead ice which was present south of the moraine while it was being deposited.

Paint Creek Valley—The valley of Paint Creek in southern Ripley and northern Monroe townships is partly filled with morainic deposits from its head to a point about half way to its mouth. The lower part of

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[1] Andersen, S. A., Om Aase og Terrasser inden for Susaa's Vandomraade: Danmarks Geol. Undersogelse, II Raekke, Nr. 54, 1931.

[2] Brown, T. C., The Waning of the Last Ice Sheet in Central Massachusetts: Jour. Geol., Vol. 41, pp. 144-158, 1933.

the valley is more thinly covered with ground moraine and is barren of morainic topography, except for two small areas about a mile from its mouth in southern Prairie Township.

A small area of morainic topography exists on the north side of Paint Creek near its mouth in NW Sec. 9 and in E Sec. 8 of Prairie Township. It rises from the valley floor to an elevation of about 960 feet and has well-developed hummocks of till. South of the creek is another small patch in NW Sec. 16 and NE Sec. 17. This tract rises abruptly from the valley floor to a rude terrace bench at an elevation of about 920 feet. This terrace-like area is billowy, but not as hummocky as the area to the north.

The upper part of the valley of Paint Creek and its tributary valleys are partly filled with drift having a hummocky or billowy surface which in places approaches knob and kettle topography. This area conforms closely to the valley pattern, being irregular in shape, as shown on the map. The main tract along Paint Creek proper is from one-half to 1 mile wide from its head in Sec. 17, Ripley Township, eastward to central Sec. 24, Monroe Township. In addition, a northward enlargement about 1 mile square is present northwest of McMillen School and three southward projections extend along unnamed tributary valleys for a distance of 1 to 2 miles. The most westerly of these projections, which might be considered a headward prong of the area in Paint Creek Valley, in Sec. 20 and NW Sec. 21, Monroe Township, and SE Sec. 17, Ripley Township, is irregular in shape. The middle one of the projections of morainic topography leaves the main area in NW Sec. 22, Monroe Township, and extends southward up the tributary valley past Phinney School, with a total length of almost 2 miles. The third of the projections, near the east end of the main area, is a belt of hummocky topography about one-fourth mile wide and extends up a tributary valley to the south, a distance of about 1½ miles. One-fourth mile west of Paint Valley village the moraine tract ends abruptly. Paint Creek, which has been flowing around and between drift knolls, here enters a flood plain which has an average width of one-fourth mile.

The boundary between the morainic topography and the ground moraine is generally at about half the vertical distance from the valley floor to the upland. This upper limit rises upstream from an elevation of about 1,000 feet to about 1,200 feet at the head of the valley.

The drift composing the morainic tract in Paint Creek Valley and its tributaries is largely pebbly till containing a few cobbles and boulders. At places, the till is sandy or gravelly, but it does not contain many gravel masses.

Ancient Mohican Valley—Part of an ancient valley, now without a major stream, extends from Loudonville in northeastern Hanover Township, Ashland County, east-northeast to Shreve, in southeast Clinton

Township, Wayne County. Its history is discussed under the topic, "Earlier Drainage Systems." As shown on the glacial map, this old valley contains a great kame terrace area, whch will be discussed separately. In addition, morainic topography exists at many places on the slopes, especially on the south, and extends up some of the tributary valleys. The best development of morainic topography in this ancient valley is in southeastern Clinton Township, Wayne County, and northwestern Ripley Township, Holmes County.

The glacial features of Wayne County have been studied by Conrey,[1] who shows in his report and on the map accompanying it that the areas of morainic topography in southern and central Wayne County are largely confined to pre-Wisconsin valleys and lowlands, and that the uplands are covered with a veneer of ground moraine. The present writer has seen much of the area of Wayne County and agrees with Conrey's careful and detailed mapping. The glacial features of the southern and western borders of the county were studied in detail, in order to correlate them properly with those of Holmes County on the south and of Ashland County on the west.

The morainic area under consideration has a width of about 1½ miles and lies along the county line on the south side of the ancient valley. The topography in secs. 26, 27, 28, and 29, Ripley Township, is hummocky near the north line of the township, but to the south the surface becomes less billowy and passes into that of the more even ground moraine at an elevation of from 1,040 to 1,100 feet. To the north in Wayne County the surface is much more hummocky and "is made up of a succession of knolls and depressions."[2] The drift of the terminal moraine tract is gravelly till near Shreve and clayey till to the southwest in Holmes County.

A broad projection of the morainic area in the main valley continues southward in northwestern Ripley Township, extending higher up the slopes than is usual. In secs. 4, 5, and 6 it reaches to within 100 feet of the upland with its veneer of ground moraine to the south and west.

The surface of the morainic area is, in general, one of only moderately developed knolls and depressions, but a small elongate area of low kames and a tiny esker are present in E Sec. 6. The hill about 1 mile south of Big Prairie in Sec. 29 is not included in the moraine tract because it is bedrock very thinly veneered with till and exhibits little in the way of constructional surface.

The morainic topography south of the ancient Mohican Valley in Washington Township, Holmes County, exists as small scattered areas, in contrast to the larger, continuous, but irregular tract to the east in Ripley Township. The smaller areas in Washington Township are chiefly

[1] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, 1921.
[2] *Ibid.*, p. 27.

on the lower slopes between the kame terrace deposits of the valley floors and the ground moraine of the upland. Their upper limits are mainly below 1,040 feet in elevation. Along the line between secs. 34 and 35 is a high bedrock hill with a veneer of drift, forming the end of the upland between Lake Fork and Crab Run valleys. On the west the veneered hill slope comes down to Lake Fork, but on the north, east, and south a belt of hummocky topography about one-fourth mile in width is present on the lower slopes of the hill. To the north and east the morainic belt lies between a kame terrace and the bedrock hill. To the south it occupies a depression between the bedrock hill and the more extensive upland farther south.

Another small patch of hummocky topography extends for about 1 mile along the east side of Lake Fork Valley in NE Sec. 4 and SE Sec. 33. It is banked against a rock hill to the east and rises above a kame terrace area along most of its west side.

An area of about 2 square miles of well-developed morainic topography is present south and southeast of Loudonville in Sec. 7, S Sec. 6, and NW Sec. 8, Washington Township, Holmes County, and E. Sec. 12, Hanover Township, Ashland County. It is bounded on the northwest by gravel kames in the ancient Mohican Valley and on the east by the kame terrace area of Lake Fork Valley. On the west, south, and northeast are thinly till-covered uplands. This area attains an elevation of 1,240 feet in NW Sec. 8, Washington Township. The best-developed knolls are at 1,200 feet in Sec. 12, Hanover Township, where knolls 10 to 20 feet in height and undrained depressions about 10 feet deep and several acres in extent, are present. The greater part of the drift of this tract is clayey till, with masses of gravel intermixed. The gravel masses are larger at the northern border of the area where it grades into the Loudonville kame area. The area of thick drift and morainic topography south of Loudonville lies from one-half to more than 1 mile north of the glacial boundary, whose course lies along the south side of the ridge which is north of the Mohican River. This area is related to the wide ancient valley to the north rather than to the line of farthest ice advance to the south.

Crab Run Valley—Crab Run is formed by the junction of several small streams 1 mile west of Nashville, in the southeastern corner of Washington Township, and flows northward through the eastern part of the township to the ancient Mohican Valley at Lakeville. The southern half of the valley is occupied by morainic topography. Prominent knolls from 20 to 30 feet in height are present in the tributary valley south of Nashville. In another tributary valley southwest of that village a few poorly developed kettle holes are present between similar knolls. From the junction of these tributary valleys 1 mile west of Nashville the morainic tract increases to a mile in width and extends northward for 1½ miles.

where its place is taken by a kame terrace. Constructional features are less prominent in the wider part of the tract north of Nashville in the main valley, although low, broad knolls exist in the central part of the valley and billowy swells rise to an elevation of about 1,160 feet. Above this elevation the slopes are smoother, the till is thinner, and the aspect is that of ground moraine.

The drift in the headwater tributary valleys is gravelly till and gravel mixed with till. Small pits in SE Sec. 23, and NE Sec. 24, Knox Township, expose dirty, cobbly gravel, not clean enough for first-grade road gravel. The drift in Crab Run Valley in southwestern Washington Township is largely till, containing only minor amounts of gravel.

A small brook rises at the west side of the tract of moraine, at the south line of Sec. 14, Washington Township, flows southwest across a narrow sand flat (shown on map) in NW Sec. 23, and enters a narrow gorge in Sec. 22, Knox Township, which leads to Sigafoos Run. The sand flat at an elevation of 1,100 feet, which decreases in elevation and dies out in the gorge, shows that this was a minor line of discharge for meltwaters from the ice blocks remaining in the valley of Crab Run in southeastern Washington Township. The fact that this spillway is of a minor character, and does not now carry the waters of Crab Run, indicates that dead ice remained in the valley of Crab Run until a drainage way was opened to the north into Lake Fork. If the lower part of Crab Run Valley had not contained ice blocks in the waning stage of glaciation, much meltwater would have flowed from it to the southwest and Crab Run would now flow south and southwest to Sigafoos Run, and not north to Lake Fork.

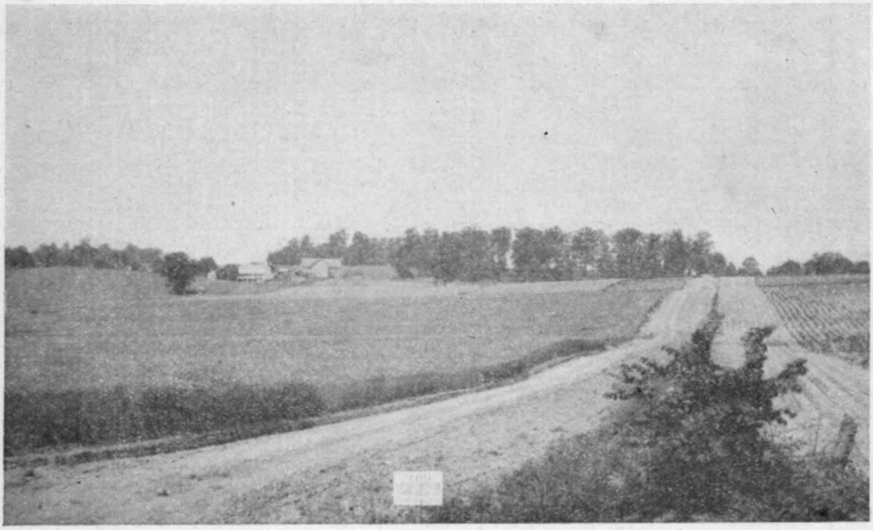
AREAS OF GROUND MORAINE

A considerable proportion of the glaciated part of Holmes County is an area of ground moraine on the uplands, interpenetrated by, or surrounded by, areas of morainic topography and of kame terrace deposits in the valleys. The county is a plateau dissected to maturity, with a relief of from 100 to 300 feet. The uplands and upper valley slopes are covered with a mantle of till which merely mask the major erosional features with minor constructional features. The ground moraine ranges from a thin, discontinuous sheet, through which the bedrock crops out, to a complete blanket 50 feet or more in thickness. The till of the ground moraine is commonly thinnest on steep slopes and sharp ridges, and thickest on wide uplands.

The surface is in most places undulating in broad, gently sweeping swells and sags which are superimposed on the regional bedrock topography. Few areas are so flat that their drainage is poor, and few undrained depressions exist. The ground moraine commonly grades into

PLATE I

A.—View looking northeast across a kettle hole and kames in valley of Martins Creek, northwestern Berlin Township, 1½ miles southeast of Benton.



P.—View looking west across ground moraine topography on the upland in southeastern Salt Creek Township, from South School, 1 mile south of Mt. Hope.

morainic deposits about halfway down the valley slopes, where the till becomes thicker and the constructional topography more dominant.

The ground moraine consists of silty till as already described. Inclusions of gravel are not common and boulders are not numerous on the surface. The till of the ground moraine areas is commonly thin, so that bedrock crops out in some ravines and road cuts. Near the glacial boundary the till becomes discontinuous. The glacial deposits of the distal one-half mile or so are commonly only scattered cobbles or boulders.

The uplands in Paint Township, in the northeastern part of the county, are covered with ground moraine having a gently undulating surface. The drift in Salt Creek Township is very thick and bedrock is concealed at most places. In fact, as much as 125 feet of drift is penetrated in some wells in the northeastern part of the township. The flattest uplands in Holmes County are in the vicinity of the village of Mt. Hope and Calamoutier in Salt Creek Township.

The uplands and slopes are somewhat thinly veneered with till in central Holmes County north of the glacial boundary and bedrock crops out at many places. This part of the county has a very imperfectly masked erosional topography. The larger features are those of a maturely eroded plateau with a relief of about 300 feet; the minor features are low constructional swells of glacial origin.

The uplands are more extensive and level in Ripley Township, where the till sheet is so thick that the bedrock is effectively concealed. The uplands in central Ripley Township are flat and in part poorly drained. Ground moraine veneers the rounded uplands in the northwestern part of the county in Washington Township. The surface ranges from smooth to somewhat billowy.

KAMES AND KAME TERRACES

As noted under the discussion of "Areas of Morainic Topography," it is believed that in Holmes County the ice sheet in the waning stage of glaciation lost all forward motion. The ice sheet melted down as well as back. The hilltops appeared first above the ice and the final stage of ice disappearance was that of blocks, in most places elongate, in the major valleys. Meltwater from the ice blocks flowed between the blocks and the valley sides. Stratified deposits, generally gravel, were laid down. Upon the final melting of the ice masses in the valleys, gravel deposits were left in terrace-like forms along the valley sides. The place of the former ice blocks remained as kettle holes. If valleys were occupied by post-glacial streams, as were most valleys, the present streams flow from one kettle hole to the next. The sides may have been more or less modified by stream erosion. If a valley was not occupied by a stream, as in the case of the ancient Mohican Valley in Washington Township, the valley floor remains much as it was when the ice disappeared. The kettle holes are the sites of swamps or lakes such as Bonnett Lake and Odell Lake.

Irregular, pitted, gravel terraces, called kame terraces in this report, are conspicuous features in many of the valleys in the glaciated part of Holmes County. They range from less than 20 feet to more than 100 feet above stream level and may exist on one or both sides of a valley. They slope downstream with a gradient of from 10 to 20 feet per mile. At their lower ends they may grade into true valley trains. Their outer boundary, which is formed by the till deposits of the steeper valley sides, is definite at some places and transitional at others. Where areas of morainic topography exist on the slopes above a kame terrace, the boundary is commonly transitional. The inner boundary is formed by great linear kettle holes, through which the stream now draining the valley usually flows. In some valleys, kettle holes are separated from each other by tracts of gravel in the center of the valley and the valley filling is there not aggregated in definite terraces along the valley walls, but takes on the character of a valley train in which huge kettle holes are found.

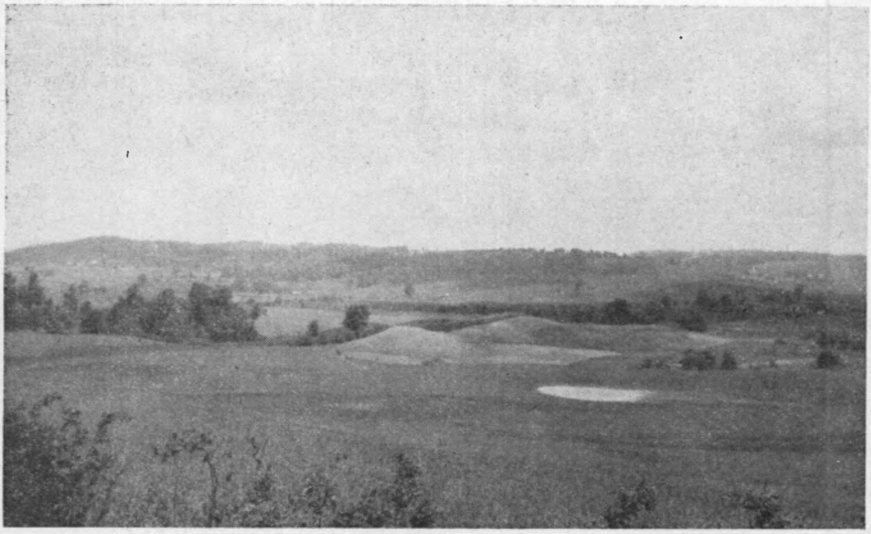
The terrace surfaces range from smooth to exceedingly hummocky. Generally, the terrace-like effect is produced by many kames, most of which rise to a general level. Hence the name "kame terrace," first used by Salisbury in 1894 for similar features in New Jersey.[1] Some terraces are so level, except for kettle holes, that they approach a pitted valley train in character. The abundance of ice blocks during the deposition of the material as indicated by the kettle holes has been the deciding factor in separating kame terraces from valley trains. Many kettle holes are present in most places ranging from those that are small and pit-like to those that are large and flat-bottomed. Hills and ridges rise at places from the bottom of the larger kettle holes and these are interpreted as kames and crevasse fillings. Kames may rise above the general terrace level. In some places the kames rise to such discordant altitudes that the area is only rudely terrace-like.

The kame terraces consist of gravel, mostly cobbly or bouldery, with irregular bedding. Locally, however, the gravel is medium to fine-grained, and the bedding is horizontal. Till masses are at most localities included in the gravel, especially in that nearest the valley wall.

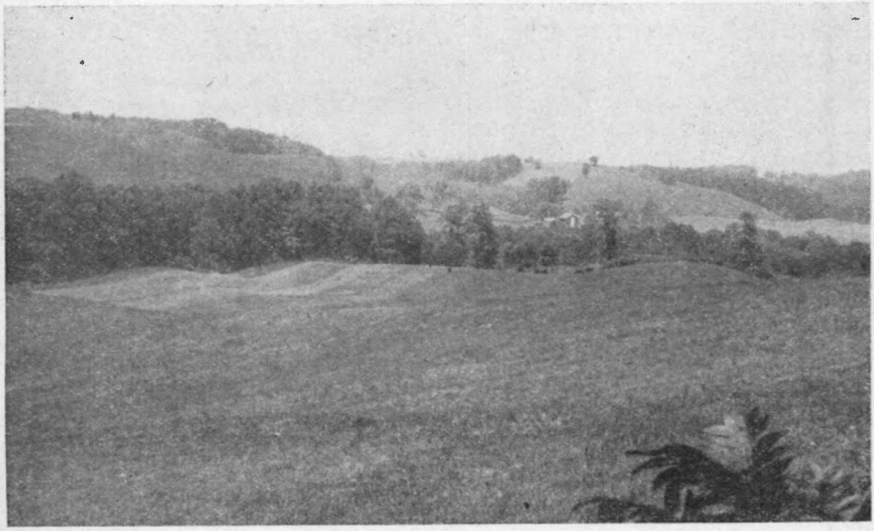
Ancient Mohican Valley—The ancient Mohican Valley, now without a major stream from Loudonville to Shreve, is occupied by extensive kame deposits. The larger, inner kettle holes have never been joined into stream courses and still remain as they were when the last ice melted. A good picture is thus given of the former conditions in other valleys since altered by stream occupancy.

[1] Salisbury, R. D., Drift Deposits Made Under the Influence of Stagnant Ice: Geol. Survey N. J. Ann. Rept. 1893, p. 156, 1894.

PLATE II



A.—View looking northwest from SE ¼ SW ¼ NE ¼ Sec. 6, Washington Township, 1 mile east of Loudonville, across kame terraces in ancient (abandoned) Mohican Valley. Note kames and kettle holes in middle ground. Hills in distance are bedrock veneered with till, forming northwest side of ancient valley.



B.—View looking northwest across kame terrace on east side of valley of Lake Fork in SE ¼ Sec. 8, Washington Township. In the distance are till-veneered bedrock hills.

The ancient valley from Shreve to Loudonville is choked with kames. In southwestern Clinton Township, Wayne County, the kame area is about 2 miles wide. Across northern Washington Township, Holmes county, and at Loudonville in Green and Hanover townships, Ashland County, the width ranges from 1 to 1½ miles. The borders of the area are very irregular and projections extend into several tributary valleys. The elevation of most of the tract is about 1,000 feet, although some kames rise to an elevation of 1,100 feet. The deposit as a whole does not have a well-marked slope in any direction. The northern and southern boundaries in northern Washington Township, Holmes County, lie in general at an altitude of 1,000 to 1,020 feet. Above that elevation the hill-sides are steeper and till-covered. In Sec. 6, Washington Township, in secs. 1 and 12, Hanover Township, and in NE Sec. 26 and NW Sec. 25, Washington Township, higher kames are banked against the hill-sides to an altitude of about 1,100 feet.

The surface is one of knob and kettle topography. Sharp kames rise 20 to 40 feet and kettle holes 20 to 60 feet deep are common. One of the largest kettle holes extends from Lakeville to Big Prairie, a distance of 1½ miles. It is three-eighths of a mile wide. Odell Lake occupies the deepest part of this depression. North of Lakeville another elongate kettle hole about a mile in length is the basin of Bonnett Lake. An extremely irregular kettle hole, 2 miles long and from one-eighth to one-half mile wide, with a marshy floor, exists in northwestern Washington Township.

The material of this kame area ranges from cobbly gravel to fine sand. The sand commonly forms small sandy flats at lower elevations and the coarser gravel is in the higher kames. Till masses are included in the gravel near the border of the area and in the higher kames. Elsewhere till is rarely present.

Lake Fork Valley—Lake Fork crosses the ancient Mohican Valley in northern Washington Township and enters a pre-Wisconsin valley in S Sec. 33, which it follows southward to the glacial boundary at the south line of the township. The pre-Wisconsin valley is partly filled with gravel, forming a well defined kame terrace on either side of the valley. The stream flows through long, narrow kettle holes centrally located between the terraces. For 1 mile south of the ancient Mohican Valley the terraces are narrow and not well developed, but in SW Sec. 4, Sec. 8, and N Sec. 17, the terraces are much better developed, and the surface is very hummocky. On either side the area is from one-eighth to one-fourth mile wide and rises 120 feet above Lake Fork to an elevation of about 1,040 feet. In S Sec. 17, the kame terraces grade into an outwash plain which continues to the Mohican River, and thru which Lake Fork has excavated a channel.

In Sec. 34 and NW Sec. 3, an abandoned valley which extends from the valley of Lake Fork to the ancient Mohican Valley contains gravel deposits. These are a part of the Lake Fork kame terrace complex and fill the valley to an altitude of about 1,020 feet. They consist of massed kames and a sharp, narrow, esker-like ridge in the center of the valley. This ridge is 30 to 50 feet high and has an irregular crest about a mile long. The esker is composed of sand and fine-grained gravel. The kame deposits of the abandoned valley of Sigafoos Run in western Sec. 9, E Sec. 10, and SE Sec. 4 join those of Lake Fork Valley in SE Sec. 4. These deposits rise to a general altitude of 1,060 feet. At the south line of Sec. 9 they pass into a level outwash plain which continues south to the glacial boundary.

The gravel of the terrace areas is, in general, coarse and cobbly, although finer-grained gravel is present in places. Till masses in the gravel are not common near the centers of the valleys, but become more common near the borders.

Crab Run Valley—The valley of Crab Run in northeastern Washington Township contains kames and kame-terrace deposits from its debouchment into the ancient valley to a point 2½ miles upstream. The deposits fill the valley in SE Sec. 2 to such an extent that at the maximum aggradation the stream took a course across a spur on the valley side, and on cutting down, became entrenched across the rock spur for one-fourth mile. To the north, terraces are well developed on either side of the valley. The general elevation of the gravel deposits descends from 1,060 feet at the south to 1,000 feet at the north. This northward slope of the surface is very significant, as it shows that dead ice masses existed to the south, blocking the drainage, and therefore the water had to seek a northward outlet. At the southern boundary the kame area grades into an area of till knolls already described.

The surface is composed of kames 20 to 40 feet in height, but kettle holes are small and shallow. The central kettle hole in the northern part of the valley is about one-quarter mile wide and connects with another kettle hole in the ancient main valley. The gravel in the southern part is cobbly and contains many till masses. The gravel of the northern part is medium-grained and contains little till.

History—The complex kame and kame-terrace deposits in the ancient Mohican Valley and its tributaries have a complex history. The higher kames near Lakeville and near Loudonville were the first deposited. They were formed by debris dumped into moulins in the waning ice sheet. Later, the ice was reduced to elongate masses of dead ice in the central parts of valleys, around which ice-margin stream deposits were laid down between the ice and the valley walls. The drainage was in various directions. The meltwater from the ice block in Crab Run flowed northward, as emphasized above. Some of the water from the main valley escaped to

Black Fork at Loudonville; some escaped southward through Lake Fork Valley. Meltwater flowed through the now-abandoned valley in secs. 3 and 34, Washington Township, which was an important line of discharge. Some escaped by way of the pre-Wisconsin valley of Sigafoos Run to the glacial boundary and thence west through a newly cut gorge to the Mohican River. Shifting in places of discharge took place as ice blocks melted. Temporary lakes existed at various places. Before the last ice blocks near Loudonville disappeared, the drainage was concentrated along the course of the present Lake Fork. A slight change in time of melting of the last ice blocks would have established the present drainage by way of Loudonville, or another change in the order of melting might have caused the main drainage to be fixed by way of the valley of Sigafoos Run.

Killbuck Valley—Well-developed kame terraces exist on one or both sides of the Killbuck Valley in Prairie and Hardy townships. On the west side of Killbuck Valley from Rush Run, just south of the north line of Holmes County, to Paint Creek, opposite Holmesville, is a hummocky terrace about 3 miles long and about one-half mile wide. The upper limit descends from an elevation of about 960 feet at the northern end to an elevation of about 880 feet at the southern end, the terrace being from 60 to 100 feet above Killbuck Creek. The outer boundary is the smooth, steep, till-covered hillside. The surface of the terrace is one of marked knobs and kettles. Sharp knobs 20 to 40 feet in height and obconical kettle holes 20 feet or more in depth exist. The inner slope of the terrace is scalloped and pitted. Killbuck Creek now flows along the foot of the terrace. Although some erosion has taken place, most of the reëntrants are still preserved, indicating that this terrace never was much wider than it is now.

Opposite this terrace a much narrower and somewhat discontinuous terrace on the east side of Killbuck Valley extends from one-half mile north of the Wayne-Holmes county line to the point where Salt Creek enters Killbuck Creek. From the county line to Tea Run the terrace is about one-eighth mile wide. It is almost absent from Tea Run to a point about one-half mile south. It thence becomes gradually wider, being one-half mile wide at its southern end a little less than 1 mile north of Holmesville. This terrace is not as high as the one across the stream, ranging from 30 to 60 feet above the creek. The northern part of the terrace is composed of kames banked against the valley slope. The southern part, in SW Sec. 34 and NW Sec. 3, Prairie Township, is a flat area rising not more than 40 feet above the flood plain of Killbuck Creek to the west. Shallow kettle holes 10 to 20 feet deep are common in this portion of the terrace, one or two containing tiny ponds.

Another kame terrace on the west side of Killbuck Creek extends from the southern part of Prairie Township into Hardy Township. It is 2 miles long and about one-half mile wide. Its elevation ranges from 900 feet at the northern end to 880 feet at the southern end. The terrace slopes gently toward the valley wall, where a channel carrying the present drainage exists. Rounded kames 20 to 40 feet high and kettle holes 10 feet deep are present. The kettles are wide and shallow and the water drains out through the underlying gravel. The outer slope of the terrace is irregular at the northern and southern ends, but for about a mile in the central part it is quite straight, having been modified by the lateral cutting of Killbuck Creek.

A kame terrace exists on the east side of the valley from one-half mile north of the corporation line of Millersburg to the central part of the village, a distance of 1½ miles. This terrace is about one-half mile in width. It has an elevation of about 920 feet at its northern end and of about 890 feet at its southern end. The eastern boundary is formed by the till-covered hillside, and the southern boundary by morainic knolls in a tributary valley. The surface of the terrace is billowy. The inner slope is somewhat irregular, but lateral cutting of the creek and cutting for the railroad, which is located at the foot of the slope, have destroyed many of the original irregularities.

The material of these terraces ranges from dirty, bouldery, poorly sorted gravel with obscure bedding, to well sorted, medium-grained gravel in horizontal strata. Gravel of the first sort prevails at the mouth of Tea Run in northern Prairie Township, at the southern end of the terrace in northern Hardy Township, and in the terrace at Millersburg. The better sorted, more evenly bedded gravel is common in the southern end of the terrace on the west side of the valley in Prairie Township. Many till masses are mixed with the gravel, especially near the outer part of the terraces.

These terraces were deposited by a meltwater stream of considerable volume which flowed between the valley wall and a great elongate block of ice in the valley. The stream flowed on the west side of the valley in northern and central Prairie Township and in northern Hardy Township, but its course was probably on the ice in southern Prairie Township. In northern central Hardy Township the stream crossed over to the eastern side of the valley. After the ice blocks melted from the valley, Killbuck Creek swung back and forth across the valley floor and modified parts of the slopes of the terraces. The absence of crevasse fillings and kames in the central part of the valley allowed lateral cutting to go on to a much greater degree than in most of the other valleys described.

Martins Creek Valley—Kames and kame-terrace deposits occupy the valley of Martins Creek in north central Holmes County. The deposits fill the irregular lowland in northwestern Berlin Township at the head of the valley and continue downstream to its mouth.

A rudely circular area of kame deposits about 2½ miles across exists in northwestern Berlin Township and in southern Salt Creek Township, at an elevation of about 1,100 feet. Two till-veneered rock hills within the tract rise above the kames. To the south, the kame area is associated with the morainic topography of central Berlin Township. To the northwest, at Benton, the tract passes into kame terraces which extend down Martins Creek. This area has a well-developed kame and kettle topography. The kames are 40 to 60 feet high and swampy kettle holes are common. The largest kettle hole is an irregularly shaped, flat-bottomed, swampy depression about a mile in diameter, known as "The Plains." Kames rise around its borders, except on the east, where morainic knolls of till form the border. The gravel is, in general, cobbly and contains boulders and till masses.

Kames and kame-terrace deposits exist in the valley of Martins Creek from Benton, in southwestern Salt Creek Township, to its mouth in southeastern Prairie Township. On the northeastern side of the valley a narrow terrace one-quarter to one-half mile in width extends from Benton to a point 1 mile east of Holmesville. It descends in this interval from an altitude of 1,020 to 920 feet. At its northwestern end it is associated with a group of kames at the northeastern end of the Holmesville moraine, having an altitude of about 1,000 feet. The northeastern boundary of the terrace is formed by the till-covered hillsides which rise sharply above the terrace. The surface of the terrace is extremely rugged and there is a relief of as much as 60 feet from the bottoms of the kettle holes to the tops of the conical kames. The inner border of the terrace is very irregular and forms one side of an elongate kettle hole, through which Martins Creek flows. The material of this terrace is cobbly, bouldery gravel, in fairly horizontal beds. Till masses are present but are not conspicuous.

The kame deposits on the southwest side of the valley are only rudely terrace-like. From Benton to one-half mile west of the west line of Salt Creek Township, the kame area is about one-half mile in width. The surface is hummocky, but kettle holes are rare. In Sec. 13, Prairie Township, the kame terrace area gives place to an area of sand in a spillway at an altitude of 960 feet. The spillway passes across the divide into the headwaters of Colliers Run.

In NW Sec. 12, in Sec. 11, and in W Sec. 14, kames are banked against the hillside south of Martins Creek. This area ranges from one-quarter to one-half mile in width. The upper border attains an elevation of 960 feet in Sec. 12, but decreases to 900 feet at the mouth of the valley. The surface is hummocky, but kettle holes are uncommon. The border of the area near Martins Creek is very irregularly indented and forms the south side of the large kettle hole through which the stream flows. The kame area on the south side of Martins Creek is composed of very bouldery, poorly sorted gravel with obscure bedding. Included till masses are common, especially at the upper border of the area.

History—Kames were first deposited around irregular ice masses in the headwaters of Martins Creek. The drainage was at first in no definite direction, part flowing southward and part flowing northward. Later, northwestward drainage was established on either side of Martins Creek, beside ice masses in the valley. The channel between ice in the central part of the valley and the northeastern valley wall emptied into the valley of Salt Creek in Sec. 2, Prairie Township. This channel passed east and north of the high kames at the end of the Holmesville moraine and its water thence flowed westward over ice north of Holmesville into the meltwater channel in Killbuck Valley. The drainage on the south side of the valley was between the central ice block and the south valley wall to Sec. 13, Prairie Township, where it passed through the divide and entered Colliers Run. Little material was transported through this spillway, however, as there is no gravel and only a small amount of sand south of the divide. This indicates that from Benton to the spillway a shallow lake existed rather than a stream. On the south side of Martins Creek, from the spillway to the mouth of the valley, the drainage was restricted to separate small streams from the ice block to the north, and these built separate kames.

VALLEY TRAINS AND OUTWASH PLAINS

Valley trains and valley-train remnants exist in several valleys in Holmes County. Most of the valley trains are outside the Wisconsin boundary, but some have their origin a few miles within the boundary. Many of them are continuations of kame terrace deposits, as has already been noted. The valley train deposits were laid down by meltwater from the ice, but not in association with ice blocks, as were the kame terraces. Post-Wisconsin stream erosion has dismembered the valley trains into terraces along the valley walls or into terrace remnants. The material of the terraces is, in general, medium- to fine-grained gravel. Minor amounts of sand are present.

Doughty Creek Valley—A few small remnants of a valley train are present in the valley of Doughty Creek in southern Berlin Township. The outwash heads at an elevation of 1,040 feet at the end-moraine which marks the Wisconsin boundary at Wise School. Its elevation decreases to 1,020 feet at the south line of Berlin Township. In northeastern Mechanic Township, Doughty Creek flows through a narrow gorge, in which no outwash is present. South of the gorge, in southern Mechanic Township and northeastern Clark Township, Coshocton County, outwash terraces exist southwest to the junction of the valley with the Killbuck Valley in Coshocton County. The elevation of valley-train remnants declines from 920 feet south of the gorge to 860 feet near the mouth of the valley. The gravel is very sandy, containing few pebbles more than 3 inches in diameter.

Killbuck Valley—Remnants of a valley train exist at the Wisconsin boundary in the Killbuck Valley 1 mile south of Millersburg and continue downstream to the mouth of the valley in central Coshocton County. The terrace on the west side of the valley, which heads at the glacial boundary, is 2 miles in length and ranges from one-quarter to one-half mile in width. It rises 90 feet above the creek. Smaller terraces are present on the east side of the valley near the glacial boundary. At the village of Killbuck, a terrace on the east side of the valley is 2 miles long and three-eighths mile wide.

Shrimplin Creek Valley—Outwash gravel exists in the lower part of the valley of Shrimplin Creek in southeastern Monroe and northern Killbuck townships. Narrow terraces head at the glacial boundary half a mile southeast of Welcome and continue almost to the mouth of the stream. A larger outwash remnant, having an area of about 1 square mile, is present near the mouth of Shrimplin Creek, between that creek and Black Creek. The terraces decrease in elevation from 920 feet at the glacial boundary to 880 feet at the mouth of the valley. The gravel is cobbly.

Mouth of Lake Fork Valley—Outwash deposits rise 120 feet above Lake Fork near its mouth, at the glacial boundary in southern Washington Township. They are a continuation of a kame terrace in Lake Fork Valley north of the glacial boundary. On the east side of the stream is a terrace one-half mile in length and one-fourth mile in width whose altitude is 1,020 feet. West of the stream, in SW Sec. 17 and SE Sec. 18, Washington Township, outwash at the same elevation extends to the Mohican River. The gravel is very cobbly, many cobbles having a diameter of 8 inches and some of 1 foot.

PART II

STRATIGRAPHY AND MINERAL RESOURCES

MISSISSIPPIAN SYSTEM

The oldest rocks exposed in Holmes County are of Mississippian age. They make up the surface beds of the lower parts of the Killbuck and tributary valleys in the central part of the county and of a greater proportion of the valley walls and hillsides in the western part. The Mississippian formations are of the upper part of the Waverly series and, following the classification of Hyde[1] and Conrey,[2] the following units have been recognized:

MISSISSIPPIAN SYSTEM	Thickness Ft.
Maxville limestone. Not present; cobbles occur in Harrison member.	
Waverly series	
Logan formation	
Vinton member. Sandstone, fine-grained	200±
Allensville member. Conglomerate	1±
Byer member. Sandstone, fine-grained	35
Berne member, Sandstone, coarse to conglomeratic	2-10
Cuyahoga formation	
Black Hand member. Shale, with minor sandstone layers.	50±

Since the Mississippian rocks crop out at lower elevations, the lower members are near stream level and in many places concealed by glacial or fluvial deposits. Satisfactory long sections from the lowest strata above drainage to the overlying Pennsylvanian rocks are rarely exposed. West of Holmes County, in the valley of Clear Fork of the Mohican River, excellent exposures are provided in the gorge-like valley, and, because of the westward rise of the beds, more of the Cuyahoga formation is above drainage. An early study by Herrick[3] of the section at Lyons Falls, a few miles west of Holmes County, differentiated the members, which include all those of Holmes County. Formation names as used currently are supplied in brackets in Herrick's section:

[Logan formation]	
[Vinton member]	
Unexposed	20 ft.
Ferruginous zone with *Phillipsia seraticaudatus*, etc.	10 ft.

[1] Hyde, J. E., Stratigraphy of the Waverly Formation of Central and Southern Ohio: Jour. Geol. Vol. 23, pp. 656-661, 1915.

[2] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, p. 49, 1921.

[3] Herrick, C. L., Geology of Licking County, Ohio. Part IV. Waverly Group: Bull. Sci. Lab. Denison Univ., Vol. IV, Pt. I, pp. 101-102, 1888.

Shales and freestone	20 ft.
Freestone, fossils of Upper Waverly	10 ft.
Shales and freestone	8 ft.
Massive freestone with *Productus arcuatus*	10 ft.
Shales and freestone	50 ft.
Allensville member	
CONGLOMERATE II	18 in.
[Byer member]	
Sandy shale, *Prothyris meeki, Allorisma,* etc	5 ft.
Shale	3 ft.
Freestone, with a parting of shale, *Syringothyris*	27 ft.
[Berne member]	
CONGLOMERATE I	18 in.
[Cuyahoga formation]	
[Black Hand member]	
Shaly and siliceous layer	10 ft.
Blue shale "lamellibranch layer?" siliceous flags	30 ft.
Concretionary shale with *Spirifer marionensis,* etc.	30 ft.

The section in Holmes County closest to the Lyon Falls section was measured just east of the Ashland County line along a road from Spellacy, in NE¼NW¼ Sec. 19, Knox Township, to the hilltop in NE¼SE¼ Sec. 18, Washington Township, extending from the Cuyahoga formation through the Logan formation to the overlying Pennsylvanian beds. The Allensville member is either concealed or absent, but otherwise the section which follows correlates very well with that at Lyon Falls:

	Ft.	In.
Pennsylvanian system		
Pottsville formation		
Shale, sandy; and covered	10	0
Clay shale, ferruginous	3	0
Clay shale, gray	5	2
Shale, gray, fissile	2	6
Clay, gray, plastic, *Harrison* horizon, altitude 1,170 feet	1	0
Mississippian system	Ft.	In.
Logan formation		
Vinton member		
Sandstone, olive, fine-grained; in 2-inch beds	14	4
Sandstone, olive, fine-grained; in 4- to 6-inch beds on weathered surfaces but more massive in fresher portions	39	8
Sandstone, buff, fine-grained; 1-inch beds; a few 1-inch layers of gray shale	39	8
Shale, gray to buff; with irregular 1- to 3-inch sandstone layers	22	8
Sandstone, buff to olive; in 2- to 4-inch layers	37	2
Sandstone, olive gray; in 1- to 3-inch layers, with 1-inch shale partings between	19	6
Allensville member		
Absent or covered.		

Byer member		
Sandstone, fine-grained, thin-bedded; upper part covered and may include Allensville member	30	4
Berne member		
Sandstone, buff, coarse, hard; unconformity at base	10	0
Cuyahoga formation		
Black Hand member		
Shale, gray, soft; with thin sandstone layers in lower part	22	0
Sandstone, gray, hard	1	6
Shale, gray; with thin sandstone layers	21	2
Road fork at Spellacy		

In the central part of Holmes County the best exposures of Mississippian rocks are in the valley of Salt Creek in northeastern Prairie Township. A section measured from the creek in SE¼SE¼ Sec. 25, Prairie Township, eastward up a ravine to the upland in SW¼SW¼ Sec. 30, Salt Creek Township, shows the character of the Mississippian and overlying Pennsylvanian strata. The absence of the lower part of the Pottsville formation is noteworthy in the section which follows:

Pennsylvanian system	Ft.	In.
Allegheny formation		
Limestone, *Putnam Hill*	3	6
Coal, good } *Brookville*	1	2
Shale } *Brookville*	0	2
Coal, good } *Brookville*	1	4
Pottsville formation		
Clay and covered	11	3
Shale, gray	5	0
Clay, carbonaceous, *Tionesta* coal horizon	2	2
Clay, gray, plastic, good	3	0
Covered	13	3
Sandstone, shaly	14	3
Clay shale, blue gray, soft	0	6
Coal, weathered, *Bedford*	0	9
Clay, gray, sandy	1	0
Shale, gray, siliceous	8	10
Clay, yellow	1	0
Covered	26	8

Mississippian system	Ft.	In.
Logan formation		
Vinton member		
Sandstone, olive, massive, fine-grained	18	2
Sandstone, ferruginous and calcareous, fossiliferous	0	4
Covered	8	0
Sandstone, fine-grained, massive	37	4
Sandstone, fossiliferous	0	6
Sandstone, calcareous, very fossiliferous	0	10
Sandstone, fine-grained, fossiliferous	4	2
Sandstone, shaly	3	3
Sandstone, massive	10	9

Covered	17	0
Sandstone, fossiliferous	0	3
Sandstone, fine-grained, massive	9	7
Sandstone, fossiliferous	0	2
Sandstone, shaly	3	7
Sandstone, buff, massive	22	5
Shale, gray, siliceous	0	4
Sandstone, thin-bedded	0	7
Sandstone, shaly	8	4
Allensville member		
Conglomerate, upper part fossiliferous	0	5
Sandstone, buff, coarse, massive	3	3
Byer member		
Shale, blue gray, siliceous	3	6
Sandstone, blue gray, fine-grained, upper 6 inches fossiliferous	2	0
Shale, dark blue gray, siliceous	3	0
Shale and covered	8	6
Sandstone, fine-grained	3	0
Level of Salt Creek, altitude 910 feet.		

CUYAHOGA FORMATION

BLACK HAND MEMBER

The Cuyahoga formation extends from the Sunbury shale to the base of the Logan formation. Only the upper few tens of feet crops out in Holmes County, and this represents the upper part of the Black Hand member. This uppermost Cuyahoga member varies laterally in Ohio from coarse sandstone facies to shale facies.[1] North of Holmes County, in central Wayne County, the Black Hand sandstone facies passes into a shale facies,[2] which continues southwestward across Holmes County to southwestern Ashland County where coarse sandstone again appears[3] to continue southward into Knox County.

The Black Hand shale member of the Cuyahoga formation is present just north of Holmes County in Wayne County in the valley of Killbuck Creek near stream level,[4] and therefore must be present in the Killbuck Valley in northwestern Prairie Township of Holmes County. However, all rock outcrops are concealed by alluvium and glacial drift and the presence of the member cannot be confirmed. Similarly, in northwestern Ripley Township and northern and northwestern Washington Township Upper Cuyahoga beds are probably present but their outcrop is concealed by extensive glacial deposits. Outcrops of Black Hand shale are present near stream level in the valley of the Mohican River in northwestern Knox Township, near Spellacy, where approximately 50 feet of gray

[1] Hyde, J. E., *op. cit.*, pp. 664-681.
[2] Conrey, G. W., *op. cit.*, p. 57.
[3] Lord, R. C., The Black Hand Formation in North Central Ohio: Ohio Jour. Sci., Vol. 36, pp. 124-129, 1936.
Holden, F. T., Lower and Middle Mississippian Stratigraphy of Ohio: Jour. Geol., Vol. 50, Fig 2, p. 43, 1942.
[4] Conrey, *op. cit.*, Map III.

shale with thin sandstone layers interbedded represents the member. The relation of the member to the overlying units is illustrated by the section at Spellacy already given.

Under cover in Ohio the sandstone facies of Black Hand is known to the driller as the Big Injun sand. The Black Hand shale of the outcrop in northwestern Holmes County passes into sandstone at some place under cover to the east and southeast, for Big Injun is reported from drilling for water at the Blum residence on the Killbuck Road at the south margin of Millersburg. The Big Injun sand was encountered at a depth of 240 feet and contained soft water.[1] Since the ground level at this location is approximately at the horizon of the top of the Logan formation, the position of the top of the Big Injun sand corresponds reasonably well with the top of the Black Hand shale at the outcrop at Spellacy, where it lies 213 feet below the top of the Logan formation, as shown in the section already given.

LOGAN FORMATION

The Logan formation, first named by Andrews[2] as the "Logan sandstone group" and redefined by Hyde,[3] has been traced across a large part of its outcrop in Ohio as a remarkably persistent formation of four clastic members. Hyde states as follows:[4]

"The Logan formation consists of fine-grained sandstones, shaly sandstones, and sandy shales, with only minor amounts of coarse material. It is readily divisible into four members, three of which can be traced, with changes but without loss of essential character, from the Ohio River in Scioto County to Wayne County, 160 miles, and the Berne member from Vinton County to Wayne County, 120 miles. The sandstones are never as coarse as the Hocking County conglomerates of the Cuyahoga, and the shales rarely as soft and clayey as those of the Cuyahoga. The different members all carry fossils. The whole aggregate bespeaks much more uniform sea-floor conditions over wide areas, and much quieter wave and current action, such as can be readily understood on the assumption of deeper waters, farther from shore, than those which obtained in Cuyahoga time."

The Mississippian strata exposed in Holmes County are almost entirely those of the Logan formation. Its base, marked in Wayne, Ashland, and Knox counties by the Berne conglomerate, is above drainage in Holmes County only in very small areas in Prairie, Ripley, Washington, and Knox townships, and possibly in Richland Township. Following Hyde[5] and Conrey,[6] the Logan formation is divided as follows:

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[1] Chester Blum, personal communication.

[2] Andrews, E. B.: Geol. Survey Ohio Rept. of Progress 1869, p. 82, 1870.

[3] Hyde, J. E., Stratigraphy of the Waverly Formations of Central and Southern Ohio: Jour. Geol., Vol. 23, pp. 655-682, 757-779, 1915.

[4] Hyde, J. E., The Mississippian System, in Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 51, 1927.

[5] *Ibid.*, p. 44.

[6] Conrey, G. W., *op. cit.*, p. 68.

Logan formation
- Vinton member
- Allensville member
- Byer member
- Berne member

BERNE MEMBER

The Berne member is composed of conglomerate and coarse sandstone. Its outcrop is due above drainage in Prairie, Ripley, Washington, and Knox townships, and possibly in Richland Township near the Mohican River. Being near the valley bottoms its outcrop is obscured by glacial drift, especially by the massive kames and kame terraces of the Killbuck and Lake Fork valleys. Its presence in Prairie Township is probable from extrapolation from Conrey's map of Wayne County,[1] which shows it should be present near the level of Killbuck Creek south of the Wayne County line; but no outcrops have been found here. Similarly, from known outcrops in Wayne County, the Berne member should be present in northwestern Ripley Township, but rock outcrops at this horizon are concealed by glacial deposits as are those to the west in northern Washington Township. In southwestern Washington and northwestern Knox townships, at Spellacy, in the section already given, 10 feet of coarse massive sandstone resting unconformably upon Cuyahoga shale represents the Berne member.

Its presence at an elevation of 920 feet as a conglomerate 5½ feet in thickness at Edlam (Greer), in the valley of the Mohican River 1 mile west of Richland Township, Holmes County, is recorded by Holden.[2] It is described[3] as "a basal, very coarse conglomerate grading upward into fine conglomerate and a coarse to medium-grained, gray sandstone 6 to 15 inches thick. A brown to white, fine quartz gravel conglomerate caps the member." Its elevation of 920 feet at Edlam makes its presence above drainage in Richland Township questionable, except in Sec. 6, where the Mohican River enters Holmes County for one quarter mile.

BYER MEMBER

The Byer member is above drainage in parts of Salt Creek, Prairie, Ripley, Washington, Knox, and Richland townships. As it is near stream level, exposures are generally poor, due to covering by till and outwash deposits. Better exposures are found west of Holmes County in the valley of the Mohican River in Knox County. The Byer member is underlain by the Berne conglomerate and separated from the overlying Vinton member by the Allensville.

The Byer member is made up of buff to olive, fine- to medium-grained, thin-bedded sandstone, with varying amounts of fine to silty

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[1] *Ibid.*, Map III.

[2] Holden, E. T., Lower and Middle Mississippian Stratigraphy of Ohio: Jour. Geol., Vol. 50, p. 57, 1942.

[3] *Ibid.*, Lower and Middle Mississippian Stratigraphy of Ohio: University of Chicago Ph.D. Dissertation (MS), p. 40, 1941.

shale interbedded. The Byer resembles the Vinton member in appearance, and in Holmes County it is difficult to distinguish the two, as the Allensville conglomerate which separates the two sandstones is poorly developed or poorly exposed. The thickness of the member appears to be about 35 feet in Holmes County. At Edlam, in Knox County, it is 40 feet in thickness.[1] To the north, in Wayne County, it ranges from 50-80 feet.[2]

The largest areas exposed above drainage should be in Prairie Township, in the valley of Killbuck Creek, and in Washington Township in the Lake Fork drainage; but in both of these the valleys are choked with kames and kame terraces and rock outcrops are largely concealed. The character of the Byer member in Prairie Township is shown by the section already given from near Fredericksburg and that from Washington and Knox townships by the section at Spellacy.

ALLENSVILLE MEMBER

The Allensville member is a fossiliferous conglomerate lying between the Byer and the Vinton sandstones. It is very poorly developed in Holmes County and rarely identified with certainty. Its character and thickness in Prairie Township are shown in the section already given from that township. Were it not for its presence in Wayne County to the north and in Ashland County to the west, where more and better exposures farther above drainage make its study easier, there would be little reason for recognizing it in Holmes County and no reason for distinguishing between the Byer and Vinton sandstone members of the Logan formation. The character of the member in Wayne County is described by Conrey as follows:[3]

> "The Allensville is a marine conglomerate which varies in thickness from 8 to 24 inches. Although of slight thickness, its persistence over a large area makes it of equal value with the Berne member as a horizon marker, in fact, were it not for this conglomerate there would be little basis for dividing the beds above the Berne horizon, as it forms the only marked break in a long succession of fine-grained sandstones and shales. The Allensville occurs 50 to 80 feet above the Berne member, and 650 to 700 feet above the Berea sandstone. It consists of a rather firmly cemented matrix of medium to coarse-grained sandstone with quartz pebbles ranging from one-eighth to one-half inch in diameter. The contact with the underlying Byer member is a disconformity."

VINTON MEMBER

The Vinton member of the Logan formation is the Mississippian rock unit which is by far the most prominent in Holmes County. It crops out in all the townships except Paint, Walnut Creek, and Clark. Its base, marked by the Allensville conglomerate, is generally below drainage, or difficult of definition. Its top is irregular, being unconformably overlain by the Pottsville formation of the Pennsylvanian system. The thickness

[1] *Ibid.*, p. 46.
[2] Conrey, G. W., *op. cit.*, p. 78.
[3] *Ibid.*, p. 81.

of the member is variable because of the post-Mississippian erosion it has undergone, but in some places it reaches 200 feet or more.

The Vinton member is composed of a monotonous sequence of fine-grained, somewhat argillaceous sandstone, with a few shale layers 6 inches to 2 feet in thickness. The color on the outcrop is buff, tan, or olive drab; much of the rock is speckled with spots of iron oxide 1 or 2 millimeters in diameter. Where fresh, under heavy cover, the rock is bluish gray. On vertical faces which have undergone weathering for some time the layers are not immediately separated by weathering but the rock first breaks up into irregular masses about the size of large, thin bricks, bounded by irregular vertical joints and gently curved horizontal joints which do not follow bedding planes, but cut across them at a low angle.

The member is sparingly fossiliferous, the fossils being preserved as casts of the exterior. No fossiliferous zones can be followed for any distance.

Salt Creek Township—The Vinton member is above drainage in Salt Creek Township in the valley of Martins Creek in the southwestern part of the township and in the valley of Salt Creek in the central northern part. Along the western margin, just south of Wayne County, sections are exposed in valleys of streams tributary to Salt Creek, the lower parts of which are in Prairie Township. In the central northern part of Salt Creek Township, 40 feet of olive, thin-bedded, fine-grained Vinton sandstone is exposed along a road just north of the creek in NW¼NW¼ Sec. 27. Pottsville strata lie upon the Mississippian rocks. In the southwestern part of the township exposures at lower elevations are very poor.

Prairie Township.—The Vinton member is widely exposed in Prairie Township, where the best exposures are along the valley of Salt Creek. The section starting at creek level in the most southerly ravine in SE¼ Sec. 25 and extending eastward into SW¼ Sec. 30 of Salt Creek Township, already presented in the general discussion of the Mississippian system, is illustrative of the character of the Vinton member. It is largely fine-grained sandstone, with poorly exhibited bedding when reasonably fresh, but on weathering showing a thin-bedded character. A rather small proportion of the sandstone is shaly. Thin, fossiliferous zones are present as noted in the section given. A minor amount of shale is interbedded in the sandstone.

Ripley Township.—The Vinton sandstone is found in northern and in southeastern Ripley Township. Extrapolation from Conrey's map of Wayne County[1] indicates that the base of the Vinton should be present south of Shreve, but if present above drainage in Holmes County the base is concealed by drift. The best exposures in the township are in the southeastern portion, where in the valley of a tributary to Paint

[1] *Ibid.*, Map III.

Creek in SE¼SW¼ Sec. 12, 80 feet of thin-bedded, fine-grained Vinton sandstone is exposed.

Washington Township.—The Vinton sandstone is the most extensive rock unit at the surface in Washington Township. It is everywhere of fine grain, presenting the characteristic olive drab color and thin bedding upon weathering. Where fresh, units up to several feet in thickness commonly exhibit a massive appearance. The section at Spellacy, given above, is characteristic of the Vinton member where seen in Washington Township.

Knox Township.—The Vinton member is prominently exposed in northwestern Knox Township in the Mohican Valley, and in the southern part of the township in the valleys of Black Creek and its tributaries. In the Mohican Valley the base of the Vinton is above drainage, but is not clearly marked. The member has the same character as exhibited in the section at Spellacy. In southern Knox Township, just north of Glenmont, more than 200 feet of fine-grained, olive sandstone with occasionally a few inches of shale is present below the Pennsylvanian strata. The sandstone is apparently all of the Vinton member, although near stream level the Byer may crop out. This possibility, however, cannot be proved as no Allensville, which marks the base of the Vinton, was seen.

Monroe Township.—The Vinton sandstone is due, but very poorly exposed, in the valley of Paint Creek, in northern Monroe Township. Along the sides of the valley of Shrimplin Creek in the southern part of the township as much as 100 feet of characteristic Vinton sandstone is present above drainage.

Hardy Township.—Little of the Vinton sandstone is exposed in Hardy Township because the Mississippian surface is stratigraphically lower in the Killbuck Valley, and the Pottsville rocks extend downward almost to drainage level. The few feet of Logan formation present appears to include somewhat more shale than is typical of the Vinton member.

Mechanic Township.—Vinton sandstone is well exposed in the southern part of Mechanic Township in the Doughty Creek drainage. As much as 70 feet of the upper part of the member is above drainage. Some of the best exposures are in the valley of Military Run, where up to 50 feet of fine to medium-grained sandstone is exposed.

Killbuck Township.—The Vinton member is well exposed in the valleys of Killbuck, Shrimplin, Black, and Wolf creeks and those of smaller tributaries to these streams in Killbuck Township. In the northern part of the township, north of Killbuck and Black creeks, about 100 feet of thin-bedded, fine-grained Vinton sandstone is above drainage. In SW¼NE¼ Sec. 1 the member appears to be thinner bedded and to include more shaly sandstone strata than is the usual case (142-285, Appendix). South of Black Creek in central Sec. 8, 195 feet of sandstone, apparently all Vinton, lies below the Pottsville.

In the central western part of Killbuck Township, on either side of Wolf Creek, the Mississippian strata above drainage are as much as 200 feet in thickness. No features were noted which would indicate that these strata are not all Vinton. The bottom part of the beds above drainage is well exposed along the state road on the west side of Killbuck Creek from Killbuck village to the mouth of Wolf Creek. They show well the typical Vinton character of thin beds of olive to buff, fine-grained, somewhat argillaceous sandstone.

In the southeastern part of Killbuck Township the Vinton member crops out prominently, a thickness of 200 feet being above drainage near Killbuck Creek. Thin, fossiliferous zones are present in the lower part of the member exposed at an outcrop at the south end of the railroad bridge in SE¼SE¼ Sec. 25. At the base of this outcrop a conglomerate layer, 8 inches in thickness, may be Allensville and may mark the base of the Vinton member.

Richland Township.—In the valley of Black Creek in northern Richland Township, as much as 200 feet of Mississippian strata is above drainage. The beds below the Harrison, the basal member of the Pottsville formation and Pennsylvanian system, are sandstone of fine to medium texture occurring in beds from less than an inch to several inches in thickness. A few shale beds appear, but these are not conspicuous in the section. These sandstone strata are all assigned to the Vinton member of the Logan formation. The possibility is recognized that the basal portion may be Byer, but in the absence of exposures of the Allensville member, the Byer is not identified. Beds assigned to the Vinton have the same character and thickness in the valley of Wolf Creek in southeastern Richland Township.

In the western part of Richland Township, 200 feet or a little more of Mississippian strata is above drainage in the valleys of westward-flowing tributaries to the Mohican River. Those exposed in Holmes County are fine-grained sandstones with a small amount of silty shale interbedded. The sandstone is mainly Vinton, but the basal portion may be Byer.

MAXVILLE LIMESTONE

The Maxville limestone, which overlies the Logan formation at the outcrop in counties to the south and under cover in counties to the southeast, is not present in Holmes County. That it was once present, but removed before Pottsville time, is indicated by the pebbles and cobbles of fossiliferous chert and silicified limestone that occur in the Harrison member, the basal conglomerate of the Pottsville formation. Outcrops of the Harrison member containing these are common and are described in the discussion of that member.

PENNSYLVANIAN SYSTEM

The Pennsylvanian system of rocks crops out in part or all of 40 counties in the eastern part of Ohio. It is economically the most important rock system of the states in the Appalachian Plateau, for in it occur thick coal beds, including the most important single coal deposit of the world. Fire clays and shales are present in huge amounts and superior quality and on them is based the tremendous ceramic industry in which Ohio is outstanding. Sandstones are valuable for building stone, abrasive use, glass sand, and similar uses; and under cover they act as reservoirs for ground water, brine, and petroleum. Limestones are generally thin, but are a valuable resource. Iron ores were smelted in the scores of charcoal furnaces of the last century which were so important in Ohio and throughout the Appalachian states.

The rocks of the Pennsylvanian system are predominantly shales and sandstones, the total thickness of limestone, coal, and iron ore being small in proportion, but great in stratigraphic importance and economic value.

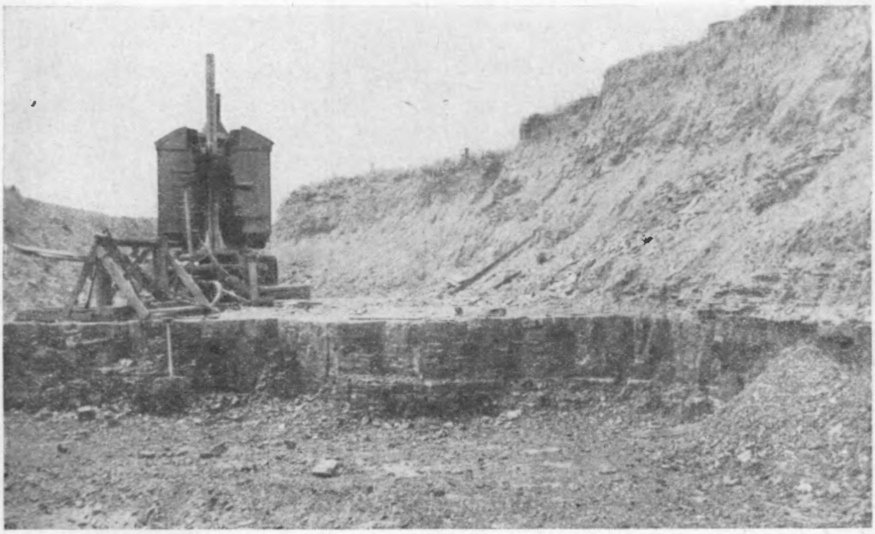
The Pennsylvanian system is divided into four formations more or less on an arbitrary basis, which is continued because it has the sanction of long-continued custom. From the base upward these formations are the Pottsville, Allegheny, Conemaugh, and Monongahela. Only the Pottsville and Allegheny formations are present in Holmes County, and the latter not in full thickness. The Pennsylvanian rocks are the predominant bedrock of the county in every township except Washington, Prairie, and Killbuck, and are the only bedrock at the surface in Paint, Walnut Creek, and Clark townships, and almost so in Berlin.

The Pennsylvanian strata lie unconformably upon the Mississippian. After deposition the Mississippian strata were uplifted and eroded to an undulating surface having a local relief of more than 100 feet. Plotting of elevations of the outcrops of the Pennsylvanian-Mississippian contact and drawing contours based on these lead to the conclusion that the Mississippian surface is most level in Washington, Ripley, and Salt Creek townships, where the relief of the ancient surface is less than 20 feet per mile over considerable areas. In Prairie, Hardy, and northern Killbuck townships the surface reaches the lowest elevations in a belt that lies approximately parallel to the present valley of Killbuck Creek. This trough is also approximately coincident with the "Millersburg" (Parkersburg-Lorain) syncline, which accentuates the apparent depth of the valley in the Mississippian surface. A branch of this depression trends northwest from Killbuck Township, where just northwest of Welcome the depression has a steep head with a relief of about 100 feet in 1 mile.

Because of the relief of the unconformity the lower Pottsville strata—the lower part of the Massillon sandstone, the Quakertown coal, and the beds below—in many places appear to be stratigraphically below the Logan beds. The basal conglomerate of the Pottsville strata, the

PLATE III

A.—Mississippian-Pennsylvanian contact in cliff along Millersburg-Holmesville state road at Hardy-Prairie township line. Massillon sandstone of Pottsville formation overlies Vinton member of Logan formation. Contact at level of man's right hand.



B.—Middle Kittanning coal exposed in Bell strip mine on Bell Ridge, eastern Knox Township, 2⅛ miles south of Ripley Township and ⅜ mile west of Monroe Township. About 2 feet of Washingtonville shale overlies the coal. Uppermost 3 feet shown in cut is weathered glacial drift.

Harrison member, thus is of different ages at different places, transcending time lines, as the sinking Mississippian surface was more and more, and finally completely, covered by Pennsylvanian sediments.

POTTSVILLE FORMATION

The Pottsville formation is the lowest and oldest group of strata in the Pennsylvanian system. Its full thickness is exposed in most of the townships of Holmes County, but in Washington and most of Richland and Ripley townships the upper part has been removed by erosion and in Paint, Walnut Creek, and Clark townships the base of the formation is under cover. The extent of the formation is shown on the geologic map of Holmes County.

The Pottsville formation is composed in large proportion of sandstones and shales, and in small proportion of coals, fire clays, iron ores, and marine limestones. The coal beds are not of importance equal to those of the overlying Allegheny formation, but the Quakertown and Bedford coals are of value. The Brookville clay is extensive and an important resource. Two of the three important marine limestones of the Pennsylvanian system in Holmes County, the Lower Mercer and Upper Mercer, are members in the Pottsville formation and are valuable stratigraphic horizon markers.

The base of the Pottsville formation, which lies unconformably upon the Logan sandstone of Mississippian age, is marked at many places by a basal conglomerate or an iron ore, the Harrison member. The top of the Pottsville formation is the base of the Brookville coal, which places the Brookville clay as the uppermost member of the formation. The Pottsville is overlain conformably by the Allegheny formation. The thickness of the formation is, on the average, 163 feet 11½ inches, but it ranges from 91 to 220 feet. An average section of the Pottsville members follows and is also shown graphically on the geologic map of Holmes County.

AVERAGE SECTION OF POTTSVILLE FORMATION IN HOLMES COUNTY

		Ft.	In.
Brookville	Clay, plastic, siliceous, fair	6	5
	Shale, and shaly sandstone; (coarse Homewood sandstone rarely present)	18	9
Tionesta	Coal, shaly, persistent	0	4½
Tionesta	Clay, plastic, gray, siliceous	4	1
	Shale, sandy	19	7
Upper Mercer	Limestone, dark blue, fossiliferous, locally flinty; locally absent	1	11½
Bedford	Coal, poor	1	0
	Clay shale	0	9
	Coal, fair	1	4½

		Ft.	In.
Bedford	Clay, plastic, siliceous, impure	3	0
	Shale, siliceous	5	11
Upper Mercer	Coal, very bony, and bone shale; locally present	1	3
Upper Mercer	Clay, plastic, siliceous, impure; locally present	1	6
	Shale, siliceous	12	2
Lower Mercer	Ore, shaly, fossiliferous	0	4
Lower Mercer	Limestone, blue, hard, fossiliferous; fairly persistent	2	10½
Middle Mercer	Coal, very shaly, persistent	0	9
Middle Mercer	Clay, plastic, siliceous	4	3
	Shale, sandy	3	1
Flint Ridge	Coal, locally present	0	7
Flint Ridge	Clay, plastic, siliceous	2	11
	Shale	10	1
Boggs	Ore, shaly, impure; commonly absent	0	6
Lower Mercer	Coal, shaly	1	5
Lower Mercer	Clay, plastic, siliceous	1	7
	Shale	6	9
Poverty Run	Ore, calcareous, rarely present	2	1
Vandusen	Coal, commonly absent	0	8
Vandusen	Clay, plastic, siliceous	3	5
	Shale	20	3
Bear Run	Coal, shaly	0	7
Bear Run	Clay, plastic	5	0
Massillon	Sandstone and shale (sandstone commonly thicker, averaging 47 ft. 10 in. and replacing Beer Run and Vandusen members)	9	1
Quakertown	Coal, fair, locally present	1	7½
Quakertown	Clay, plastic, sandy, impure	1	9
	Shale, sandy	5	2
Harrison	Ore, impure, sandy, with quartz pebbles, usually present	1	1
	Total	163	11½

HARRISON MEMBER

The Harrison member is the basal unit of the Pennsylvanian system and of the Pottsville formation. Throughout Ohio, Pennsylvanian strata rest unconformably upon those of Mississippian age, and an unknown thickness of Mississippian rocks has been eroded. In Holmes County no outcrops were seen of Maxville limestone beds, the Pottsville rocks everywhere resting upon Logan sandstone. As no Sharon conglomerate or coal is present in Holmes County, the area of the county was not submerged and deposits were not laid down in Pottsville time until just before Quakertown time, or even somewhat later on some of the higher Logan hills. In places the surface of Mississippian rocks has a relief of more than 100 feet in distance of 2 miles or less and the oldest Pennsylvanian beds are restricted to depressions in the Mississippian surface.

The basal beds of the Pottsville strata are usually (but by no means universally) conglomeratic, ferruginous, or both. The name Harrison has been given to this basal conglomerate and ore.[1] The Harrison varies in age from place to place: in southern Ohio it is pre-Sharon; in Holmes County it varies from pre-Quakertown (about Anthony?) to about Vandusen. Its usual position in the county is just under and its age is just older than Quakertown.

The Harrison member is composed of pebbles and cobbles of quartz, chert, and silicified limestone, and of coarse sand, cemented by clay material, silica, or iron compounds. The pebbles and cobbles are well rounded. The silicified limestone fragments range from a fraction of an inch to 6 inches or more in diameter. Casts of fossils are present, and from a study of these in Wayne County Conrey[2] concluded that they are derived from the Maxville limestone. Similar silicified, fossiliferous limestone cobbles have been reported in the Harrison member in Licking and Summit counties by Morse,[3] in Muskingum and Coshocton counties by Stout,[4] and in Coshocton County by Meyers.[5] In Muskingum County the Maxville cobbles in the Harrison member are angular and the deposit described as "a brecciated mass of siliceous fragments cemented by iron compounds,"[6] and such deposits are "not far distant from Maxville areas." In Coshocton and Holmes counties the cobbles are rounded, in many places perfectly so, and no Maxville strata are preserved. It is regarded as likely that before the Harrison member was deposited the surface was discontinuously covered with resistant fragments of residual Maxville material from which all carbonate had been leached. The surface had been eroded below the Maxville horizon. The residual fragments were transported by streams and currents, indicated by the rounded character of the pieces, and are not old residual mantle rock deposits, as some of those of Muskingum County appear to be. It is not without the bounds of possibility that at some place in Holmes County, as yet undiscovered, one or more buried Mississippian hills rise high enough to retain Maxville beds at the top. The careful examination of drill records and cuttings at the horizon just below the Pennsylvanian might show this condition where it exists.

The iron compounds in the Harrison member may be in separate, irregular beds up to several inches in thickness, but in many places are dispersed through the clastic material. On the outcrop the original iron carbonate is weathered to hematite or limonite. In southern Ohio ore layers in the Harrison were at places of sufficient thickness to mine for use in charcoal furnaces. In Holmes County the ore in those places where it is present in beds is much too thin to have ever had value. Distinct

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[1] Stout, W., Geology of Southern Ohio: Geol. Survey Ohio Bull. 20, p. 481, 1916.
[2] Conrey, G. W., *op. cit.*, p. 89.
[3] Morse, W. C., The Maxville Limestone: Geol. Survey Ohio Bull. 13, p. 99, 1910.
[4] Stout, W., Geology of Muskingum County: Geol. Survey Ohio Bull. 21, p. 48, 1918.
[5] Meyers, T. R., Geology of Jefferson and Bedford Townships, Coshocton County, Ohio: unpublished thesis, The Ohio State University, p. 22, 1929.
[6] Stout, W., *op. cit.*, p. 48.

ore layers are in most places only 2 or 3 inches and nowhere more than a foot in thickness. The average thickness of the member, including ore and conglomerate, is 1 foot 1 inch.

It is of interest to note that the Logan sandstone beneath the Harrison member commonly shows evidence of pre-Pennsylvanian weathering. At some places the Logan is leached for several inches or more; at others the sandstone is more or less impregnated with iron compounds.

The horizon of the Harrison member is present in every township except Paint, Walnut Creek, and Clark. Because of the stratigraphic interest of the member, it is described in some detail in each of the townships, and even where it is not developed, the character of the Mississippian-Pennsylvanian contact is noted.[1]

Salt Creek Township.—The contact between the Mississippian and Pennsylvanian rocks is above drainage in the valley of Salt Creek in the central northern part and in the extreme northwestern corner of the township, and in the valley of Martins Creek. Outcrops at this horizon, especially along Martins Creek, are obscured by glacial deposits. In a road cut northeast of Salt Creek in NW¼NW¼ Sec. 27 the basal Pottsville strata are well exposed, but no ore or conglomerate is present. The uppermost strata of the Waverly series seem a little softer and slightly more iron-stained than the layers below, probably the result of post-Mississippian erosion. A section measured here is as follows:

	Ft.	In.
Pennsylvanian system		
Pottsville formation		
Sandstone, yellowish, shaly	15	0
Sandstone, white, medium-grained, thin-bedded, somewhat irregular	6	2
Shale, white, sandy; containing plant fossils, altitude 1,080 feet	0	2
Mississippian system		
Logan formation		
Sandstone, olive drab, thin-bedded, with small iron spots	39	8
Level of Salt Creek.		

In the head of a tributary to Martins Creek, NE¼NW¼ Sec. 6, ore exposed in the stream may be the Harrison member. A section of the rock strata was measured as follows:

Clay shale, very irregular; with sandstone lenses up to 1½ feet thick and 8 feet long	20	0
Shale, black, carbonaceous, *Quakertown*	2	0
Clay, light, with plant fossils	8	0
Clay shale, dark, carbonaceous	2	6

[1] In the description of members by townships in this report the first discussion is of the most northeasterly township, Paint, and then in order westward through Salt Creek, Prairie, Ripley, and Washington townships; thence south to Knox Township; thence west across Monroe, Hardy, and Walnut Creek townships; thence south to Clark (German on older maps) Township; and thence west across Mechanic and Killbuck townships to Richland Township, the most southwesterly township. Not all townships are included in the description of some members because they may be under cover or eroded from that township. Each township description starts in the northeast part, and passes through the central north, northwest, southwest, and central south to the southeastern part of the township.

			Ft.	In.
Ore, dark blue, dense, hard	Harrison?	......	0	2½
Shale, dark		......	0	0½
Ore, dark blue, dense, hard		......	0	3
Shale, black, carbonaceous with ore balls		......	2	6
Stream level, altitude 1,000 feet				

One-half mile south of Fryburg, in the central southern part of the township, Upper Mississippian sandstone crops out along a road at an altitude of 1,050 feet, but the Harrison member is not exposed. The altitude of its horizon must be above 1,050 feet, but probably only a few feet higher.

Prairie Township.—The horizon of the basal Pottsville is due along the stream valleys in Prairie Township. The horizon is at many localities concealed by glacial drift, but where exposed it appears at altitudes from 860 feet to 1,060 feet. In the northeastern part of the township the Harrison was seen along a road in SE¼SW¼ Sec. 36, at an elevation somewhat higher than elsewhere in the township, as loose blocks of conglomeratic sandstone cemented by iron ore. The pebbles are mostly one-half inch to three-fourths inch in diameter, but a few of larger diameter were noted. The relationship to the beds above and below is recorded as follows:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Shale and covered	5	0
Clay	1	0
Sandstone, white, and covered	7	0
Clay shale, in part ferruginous, containing ore balls	5	0
Coal, bright, hard, *Quakertown,* altitude 1,060 feet	0	11
Clay shale, gray	3	0
Sandstone, coarse, white, and covered	7	5
Ore, loose blocks, containing pebbles, *Harrison*	0	6
Mississippian System		
Logan formation		
Sandstone, tan, fine-grained, massive to thin-bedded, *Vinton*	150	0

In a ravine in SE¼NE¼ Sec. 1 the Harrison has the following character:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Covered	4	4
Clay shale, dark gray, with 2 to 5-inch ore balls	1	6
Shale, sandy	1	0
Ore, impure, sandy, discontinuous, *Harrison*	0	2
Mississippian System		
Logan formation		
Sandstone, massive to 2-inch beds	16	0
Shale, gray, siliceous	4	0
Sandstone, thin-bedded to massive	17	0
Stream level, altitude 945 feet.		

In the northern part of the township, between Salt and Killbuck creeks, the basal Pottsville strata crop out at several places, but the Harrison member is poorly developed. Along the road between SE¼ Sec. 27 and NE¼ Sec. 34, loose pieces of Harrison ore are present at an elevation of 1,000 feet. Just north of Prairie Township, in central Sec. 24, Franklin Township, Wayne County, three-fourths of a mile west of Fredericksburg, the character and relationships of the member are as follows:

	Ft.	In.
Pennsylvanian System		
Allegheny formation		
Covered	28	4
Coal blossom, *Brookville*	2	3
Pottsville formation		
Clay and covered	1	0
Covered	23	8
Sandstone, medium to thin-bedded	15	10
Shale, sandy	7	6
Sandstone and covered	32	10
Sandstone, thin-bedded to shaly, weathered, iron-stained	6	2
Sandstone, white, firmly cemented, hard, quartzitic	0	5
Ore, sandy, impure, in layers } *Harrison*	0	3
Ore, nodular, sandy, impure } *Harrison*	0	2
Mississippian System		
Logan formation		
Sandstone, light gray, "shelly," clay-bonded, fine-grained; some hard layers	6	2
Sandstone, white to light gray, clay-bonded, shaly; contains oolites of iron carbonate	1	1
Sandstone, yellow-brown, shaly; irregularly bedded	0	11
Sandstone, gray; with oolites of iron carbonate, heavy	8	5
Sandstone, olive buff, fine-grained, thin-bedded, small iron spots	20	0

West of Killbuck Creek the base of the Pennsylvanian strata ranges from an altitude of about 1,060 feet in the northwestern corner to a little less than 1,000 feet in the central southern part of the township. Outcrops are usually not clear enough to show details of the strata, but the following section is exposed along the road between NW¼ Sec. 32 and NE¼ Sec. 31:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Sandstone, somewhat irregularly bedded; with carbonaceous plant fragments	8	8
Shale, sandy	1	4

			Ft.	In.
Ore, somewhat uneven, massive; grayish tan where fresh	Harrison, altitude 1,015 feet	......	0	7
Clay shale, gray		......	0	11
Shale, carbonaceous, (almost coaly)		......	0	9
Shale, ferruginous		......	1	2
Mississippian System				
Logan formation				
Sandstone, light to olive buff, thin-bedded, fine-grained, partially laminated			3	6

Along the Millersburg-Holmesville state road, just east of Killbuck Creek and north of Colliers Run, the contact between the Mississippian and Pennsylvanian rocks is prominently exposed in a cliff at the Hardy-Prairie township line. The Harrison member here is a conglomerate and coarse sandstone, as shown by the following data:

			Ft.	In.
Pennsylvanian System				
Pottsville formation				
Sandstone, coarse	Harrison			
Sandstone, very coarse		......	1	6
Conglomerate, ¼-inch, white quartz pebbles		......	0	3
Sandstone, white, coarse		......	0	11
Conglomerate, irregular; composed of ¼- to ½-inch white quartz pebbles		......	1	0
Mississippian System				
Logan formation				
Sandstone, fine-grained, buff, thin-bedded			8	0

The contact rises to the northeast and east, where three-fourths of a mile up Colliers Run at an elevation of approximately 900 feet the Harrison is represented by 1 foot of black, carbonaceous shale resting upon Logan sandy shale. One-half mile farther upstream the top of the Logan rises to an elevation of 940 feet.

Ripley Township.—Drift deposits conceal the bedrock over almost all of Ripley Township, and only meager data concerning the bedrock are available. In the northeastern part of the township the base of the Pennsylvanian system has an elevation of approximately 1,060 feet. Details of the contact are poorly exposed at most places, but along the county-line road in NW¼NW¼ Sec. 25 the basal Pottsville beds and a basal conglomerate with coal lenses and ore layers are as follows:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Shale, sandy	6	6
Shale, ferruginous	14	6
Covered	16	0
Clay and covered	1	6
Covered	5	0

			Ft.	In.
Sandstone, coarse, with white quartz pebbles from ¼ to ¾ inch; with many ore streaks	Harrison, altitude 1,060 feet	......	4	10
Ore, very sandy; with white quartz pebbles up to ¼ inch		......	2	8
Coal, weathered		......	0	3
Ore, very shaly and impure		......	0	3
Coal, weathered		......	0	2
Shale, ferruginous (almost an ore)		......	0	7
Clay, light, very sandy		......	0	5

Mississippian System
Logan formation

Sandstone, fine-grained; impregnated with iron ore	0	2
Sandstone, light, fine-grained, iron spots, thin-bedded.		

The horizon of the basal Pottsville beds is concealed by glacial drift throughout almost all of western Ripley Township. In NW¼NW¼ Sec. 4 and SW¼SW¼ Sec. 33 the Harrison is poorly developed, as shown by the record of the beds exposed in a ravine:

Pennsylvanian System
Pottsville formation

	Ft.	In.
Shale, carbonaceous, *Bear Run* horizon?	2	0
Shale, white, sandy, with plant fossils	3	6
Shale, somewhat carbonaceous, sandy	1	10
Sandstone, greenish, ferruginous	4	0
Ore, nodular	0	4
Sandstone, ferruginous	0	7
Ore, nodular	0	6
Shale, siliceous, dark	0	5
Coal, shaly, *Quakertown?*	0	3
Clay, very impure, sandy	1	9
Sandstone, white, thin-bedded and shaly, with plant fossils	1	0
Shale, gray	2	1
Shale, iron-stained, *Harrison* horizon, altitude 1,115 feet	0	2

Mississippian System
Logan formation

	Ft.	In.
Sandstone, massive	2	2
Shale	0	5
Sandstone, massive	2	2
Shale	0	5
Sandstone, massive	1	11
Shale, gray	0	9
Sandstone, thin-bedded	4	0

The base of the Pottsville strata lies at approximately 1,000 feet elevation in southeastern Ripley Township, but no detailed measurement of the basal beds could be secured.

Washington Township.—Exposures of the rock strata in Washington Township are generally concealed by the covering of glacial drift, and the Mississippian-Pennsylvanian contact crops out at very few places. Where seen, the contact ranges in altitude from 1,065 to 1,180 feet. In central Washington Township, along a road in SE¼NW¼ Sec. 3, the Harrison member, a true basal conglomerate rather than an ore, rests upon the underlying Mississippian shales, which exhibit an undulating surface. A section measured here follows:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Sandstone, coarse; with a few irregular lenses of conglomerate to 6 inches in thickness, with pebbles ½ to 1 inch, *Massillon*	27	10
Conglomerate, of ½- to 1-inch white quartz pebbles; matrix of coarse sand, *Harrison,* altitude 1,065 feet	6	2
Mississippian System		
Logan formation		
Sandstone, brown to yellow, thin-bedded; upper 1 foot shows ancient weathering	8	0

Along the state road in SW¼NE¼ Sec. 6 the Harrison member rests upon the Mississippian strata at an altitude of 1,160 feet, where the member is a conglomerate 2 feet 6 inches in thickness, and is overlain by 17 feet of massive Massillon sandstone. The conglomerate is composed of quartz and silicified Maxville limestone pebbles in about equal proportions. The quartz pebbles range from one-eighth to 1 inch in diameter and the cherty limestone ones from 1 to 4 inches. The silicified limestone is bleached white, and well-preserved fossils are present. In NE¼NE¼ Sec. 6 the Harrison member is much thinner, as shown by the following data obtained where the strata crop out along a lane:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Clay shale, ferruginous	4	0
Shale, black, carbonaceous, hard, fissile; somewhat ferruginous in upper part	8	2
Sandstone, gray, clay-bonded	1	4
Conglomerate, of pebbles of white quartz to ¾ inch, *Harrison,* altitude 1,140 feet	0	4
Mississippian System		
Logan formation		
Sandstone, shaly	20	0

In NW¼NE¼ Sec. 7 the conglomeratic phase of the Harrison crops out boldly along a road 200 yards northeast of Germany School. The conglomerate is iron-cemented and stained reddish brown, but with only a little ore present. The Mississippian rocks are not exposed beneath the conglomerate but a short distance to the east Mississippian rocks are poorly exposed at an elevation just below that of the conglomerate. The details are as follows:

			Ft.	In.
Sandstone, buff, coarse			4	0
Conglomerate, 1- to ¼-inch white quartz and many 2- to 4-inch fossiliferous chert pebbles (Maxville)	*Harrison,* altitude 1,130 feet		1	6
Sandstone, buff, coarse, with 2- to 3-inch conglomerate layers			5	6
Conglomerate, ¼- to ½-inch white quartz pebbles, very well rounded, with siliceous limestone pebbles			0	10

In SW¼ Sec. 18, near the Ashland County line, the base of the Pennsylvanian system has an altitude of approximately 1,170 feet, but no Harrison ore or conglomerate was observed.

One and one-half miles west of Nashville the base of the Pottsville strata was noted along the road between SW¼ Sec. 14 and SE¼ Sec. 15 at an elevation of approximately 1,170 feet, but details of the strata are too poorly exposed for clear observation.

Knox Township.—The Harrison horizon is due along the valleys in north central Knox Township and nearer the ridge tops in the western and southern parts of the township. In SW¼SW¼ Sec. 21 the Harrison member is poorly exposed at an altitude of approximately 1,190 feet. One and one-half miles westward, west of the Mohican River, the base of the Pottsville strata, again poorly exposed, is present in SW¼ Sec. 19 near Mosher School, and lies at an elevation of 1,180 feet. At a cross-road in NE¼SW¼ Sec. 30 the Harrison member, although not well exposed, appears to be represented by ferruginous shale. Several thin beds of ore are present in the section not far above the base of the Pottsville, and their correlation is uncertain. The rock section measured here is as follows:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Ore, nodular, weathered; and covered	1	0
Coal, fair, weathered	0	2
Clay shale, carbonaceous	0	10
Clay, light, plastic	2	0
Shale and covered	5	4
Shale, carbonaceous; and covered	2	5
Ore, nodular	0	4
Clay	0	3
Sandstone, white, hard, clay-bonded; contains a few plant fossils	3	6
Clay, and weathered clay shale	5	2
Ore, gray black, hard, dense, heavy; many minute glistening surfaces	1	6
Clay and covered	2	0
Clay shale, ferruginous; and covered, *Harrison* horizon, altitude 1,230 feet	11	6
Mississippian System		
Logan formation		
Sandstone, thin-bedded	20	0

In central western Knox Township the base of the Pottsville strata lies at an elevation of 1,210 feet along the road just north of the north line of partial Sec. 15, but no ore or conglomerate is developed. In the southwestern part of the township, along the road south of Germany School in NE¼ Sec. 25, a few inches of weathered ore marks the Harrison horizon at an elevation of 1,200 feet. In central southern Knox Township, one-half mile north of the Richland Township line and 1 mile south of Cross School, the Mississippian-Pennsylvanian contact has an elevation of 1,100 feet, but no indication of ore or basal conglomerate was observed. In the extreme southeastern corner of the township, along a road 100 yards north of Richland Township and one-eighth mile west of Monroe Township, 1 mile northeast of Glenmont, the character and position of the Harrison member are as follows:

		Ft.	In.
Pennsylvanian System			
Pottsville formation			
Sandstone, medium-grained, rather irregular, thin to medium-bedded		20	0
Sandstone, coarse; with a few ¼-inch quartz pebbles	*Harrison,* altitude 1,160 feet	0	2
Ore, irregular, nodular, somewhat cherty		0	3
Mississippian System			
Logan formation			
Sandstone, olive, fine-grained, with small iron spots; in 1- to 2½-inch beds; lower part poorly exposed		130	0

In central eastern Knox Township the base of the Pottsville has an elevation ranging from 1,100 to 1,180 feet, but the Harrison is either concealed or not conspicuously developed as a basal conglomerate or as an ore. A few loose pieces of Harrison ore occur in a ditch along the Glenmont road, 2 miles south of Nashville, at an altitude of 1,180 feet.

Monroe Township.—The Harrison horizon is due in the northern part of Monroe Township along the valley of Paint Creek, but is concealed. To the south, the Pennsylvanian-Mississippian contact is exposed along the valleys of Shrimplin Creek and its tributaries, and in the headwaters of tributaries flowing south to Black Creek. Along the valley of Shrimplin Creek the contact varies markedly in elevation from 1,050 feet one-quarter mile northeast of Welcome, to 960 feet 1 mile northwest, thence rising 110 feet in a mile farther northwest. Ore or conglomerate is not conspicuous above the contact, although a few inches of impure ore crops out along the road 2 miles northwest of Welcome and 1 mile south-southeast of Phinney School.

The systemic contact rises from the low elevation 1 mile northwest of Welcome to 1,035 feet 1½ miles southwest, and to a general elevation of 1,100 feet in the northwestern and central western parts of the township. In the extreme southwestern corner of the township the elevation of the contact is 1,160 feet. The basal Pennsylvanian beds in Monroe Township are only slightly conglomeratic or ferruginous.

Hardy Township.—The Pennsylvanian-Mississippian contact crops out along the valley of Killbuck Creek and extends up the major tributary valleys from 1 to 2 miles. Its elevation ranges from 840 to 860 feet near Killbuck Creek, rising to more than 900 feet both east and west of Killbuck Creek. At the Prairie-Hardy township line the Harrison member occurs as a conglomerate at an elevation of 860 feet along the Holmesville road on the east side of the creek, as described in the discussion of Prairie Township. One and three-eighths miles southeast, along a road one-fourth mile east of Honey Run School, the base of the Pottsville formation has an altitude of approximately 915 feet, but the Harrison member is not clearly exposed.

West of Killbuck Creek the Harrison member is concealed by drift at most places along the valley, but its elevation is below 880 feet and may be as low as 840 feet. An exposure at a road cut at the old reservoir one-half mile west of the northwest corner of the Millersburg corporation line shows a considerable development of conglomerate. Pebbles and cobbles of weathered, silicified, fossiliferous Maxville limestone as large as 4 inches in diameter are present. The clay shale underlying the conglomerate appears to be ancient soil, and the Waverly sandstone below bears signs of pre-Pennsylvanian weathering. The details of the strata are as follows:

		Ft.	In.
Pennsylvanian System			
Pottsville formation			
Sandstone, coarse, 2- to 4-inch beds		4	0
Conglomerate, pebbles mostly white quartz to ¼ inch	*Harrison,* altitude 840 feet	0	2
Sandstone, coarse		0	5
Conglomerate, pebbles mostly quartz		0	3
Sandstone, massive, very coarse		2	6
Conglomerate, with chert pebbles to 4 inches		2	2
Ore, dark red, with subangular pebbles		0	2
Clay shale, with a few fragmentary plant fossils		0	6
Mississippian System			
Logan formation			
Sandstone, weathered to yellow brown		1	0

One mile west of the above outcrop, in the road bank of the Loudonville road, 300 yards east of the junction of Bear Run and Corns Run, the Harrison member is 50 feet higher in elevation, and shows the following character:

	Ft.	In.
Drift	10	0

Pennsylvanian System			
Pottsville formation			
Clay shale		2	0
Ore, sandy, impure	*Harrison,* altitude 890 feet	1	2
Shale, gray, siliceous		5	6
Sandstone, coarse, massive		0	10
Conglomerate, ¼-inch white quartz pebbles; iron-stained		1	2
Ore, very impure, sandy to conglomeratic		0	6
Mississippian System			
Logan formation			
Sandstone, gray, weathered, soft		0	2
Sandstone, olive, shaly, fine-grained		2	4
Sandstone, olive, thin-bedded, fine-grained		7	0

On the west side of Killbuck Creek, southwest of Millersburg, outcrops at the Harrison horizon are concealed by glacial drift. East of Killbuck Creek the member crops out at several places. At the southeast margin of the county seat, in the ravine in NW¼NW¼ Sec. 20, the following section is exposed:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Sandstone, coarse; and covered	2	0
Ore, sandy, with purer nodules to 2½ inches, *Harrison,* altitude 855 feet	0	6
Mississippian System		
Logan formation		
Sandstone, buff, moderately fine-grained; in ½- to 4-inch beds	15	0

Along the state road 2 miles south of Millersburg, in SE¼SW¼ Sec. 22 the following measurements were made:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Shale, black, hard, platy	1	0
Ore, sandy, *Harrison,* altitude 840 feet	0	8
Clay, soft, gray	0	6
Mississippian System		
Logan formation		
Sandstone, shaly, cross-bedded	4	0
Road level.		

The altitude of the Harrison member rises eastward to about 900 feet along Sand Run and its tributaries in SW Sec. 25, where fragments of ore and silicified limestone pebbles were noted.

Mechanic Township.—The contact between the Mississippian and Pennsylvanian rocks is above drainage in the eastern and southern parts of Mechanic Township along Doughty Creek and its tributaries, and in the northwestern corner of the township near Killbuck Creek. Significant development of ore or conglomerate at the Harrison horizon is absent. The base of the Pennsylvanian strata crops out in the vicinity of Becks

Mills in the central eastern part of the township at an altitude of about 925 feet. The Harrison member is absent, as shown by the following data measured in a road bank at Becks Mills in NW¼ Sec. 11:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Sandstone, thin-bedded to shaly	15	0
Shale, ferruginous, with 2- to 6-inch sandstone layers	10	0
Sandstone, white, clay-bonded, hard, altitude 925 feet	0	6
Mississippian System		
Logan formation		
Sandstone, fine-grained, thin-bedded, iron-stained, much weathered	1	6

West of Becks Mills, in N Sec. 13, the base of the Pottsville rocks lies at an altitude of 960 feet, but the poor exposures do not reveal the presence of the Harrison member. The base of the Pottsville is above drainage along Doughty Creek from Becks Mills to Clark, its altitude descending from 985 feet in SW¼NE¼ Sec. 19 to 840 feet at Clark, and to a lower elevation southwestward in Coshocton County. North of Clark the elevation reaches almost 900 feet. The Harrison member appears to be very poorly developed, either as an ore or as a conglomerate, in the Doughty Creek drainage.

In the northwestern corner of Mechanic Township, the base of the Pottsville strata has an elevation of about 840 feet in Sec. 2, but the horizon is concealed by outwash deposits or is poorly exposed. No indication of Harrison ore was seen.

Killbuck Township.—The contact between the Pennsylvanian and Mississippian strata is above drainage throughout Killbuck Township. At places the contact is marked by Harrison ore or conglomerate; at others no Harrison member is developed and Pennsylvanian sandy shale or sandstone lies directly upon the Mississippian sandstone. The elevation of the contact ranges from 820 to 840 feet in the northeastern corner of the township (south of Killbuck Creek) to approximately 1,040 feet in the extreme northwestern and southwestern corners of the township. The contact is markedly irregular: a pre-Pennsylvanian valley of considerable size is present in northern Killbuck Township and another, somewhat smaller, exists in the central and southern part.

In the northeastern corner of the township the base of the Pennsylvanian rocks lies at an elevation of 820-840 feet south of Killbuck Creek and at 910 feet north of the creek, but no special development of the Harrison member was noted. In a ravine in SE¼SW¼ Sec. 8 the Harrison is a coarse, sandy ore 1 foot 2 inches in thickness, lying 95 feet below the Lower Mercer limestone (See 148-31, Appendix).

One-half mile southeast of Killbuck village, in SW¼NE¼ Sec. 15, the Harrison member is both ferruginous and conglomeratic (147-273, Appendix). One mile north of Killbuck village, in NE¼SW¼ Sec. 5, a poor exposure in a road ditch shows 1 foot of sandy ore, associated with conglomerate and coarse sandstone lying upon Logan sandstone at an elevation of 940 feet (141-288). The Harrison lies 115 feet below the Bedford coal. In SW¼NE¼ Sec. 1, one mile to the west, the Harrison has the same general character, but its elevation is approximately 980 feet.

In NE¼ Sec. 3 and NW¼ Sec. 2, at the Monroe Township line, the base of the Pottsville formation lies at an elevation of approximately 1,000 feet, but it has no conspicuous development of ore or basal conglomerate. In the central western part of the township the elevation of the systemic contact ranges from 1,030 to 1,050 feet, but basal conglomerate is inconspicuous or absent. In the southwestern corner of Killbuck Township, along a road in SW¼ Sec. 23, at the Richland Township line, many loose nodules of light blue to cream-colored flint from 2 to 6 inches in diameter are scattered over the surface at an altitude of 1,030 feet, at the Harrison horizon, but no clear section of the bed or of those above or below can be seen.

In the central southern part of the township outcrops of the Harrison member range in altitude from 980 to 1,020 feet. Cobbles of silicified, fossiliferous Maxville limestone are especially conspicuous in the member in SW¼ Sec. 21 (146-346).

In the southeastern part of Killbuck Township the base of the Pottsville strata ranges in elevation from a little more than 900 feet in Sec. 18 to approximately 1,010 feet in SE¼NW¼ Sec. 24. Loose pieces of flint derived from the Harrison conglomerate are present in central Sec. 18, but the member was not located in place.

Richland Township—The Mississippian-Pennsylvanian contact is above drainage along the major and most of the tributary stream valleys. Basal conglomerate or ore is discontinuous laterally. The altitude ranges from about 1,040 feet in the eastern part of the township to about 1,140 feet in the western part. In the northeastern part of the township, in a ravine and along a road in SE¼SW¼NW¼ Sec. 4, six inches of impure sandy ore lies upon the Waverly strata and is overlain by massive Massillon sandstone at an altitude of about 1,080 feet. One mile northeast of Glenmont, at the Knox Township line, the Harrison member has an altitude of 1,160 feet and 1 mile west of that village the elevation of the Harrison horizon is 1,100 feet. In the northwestern corner of the township, in SW¼NW¼ Sec. 5, the Harrison member is at an elevation of 1,220 feet.

In the deep cut at Baddow Pass, in SE¼NE¼ Sec. 14, through which the Pennsylvania Railroad crosses the divide between the Mohican drainage and the Black Creek (Killbuck) drainage, the systemic contact is well exposed. The contact has a relief of more than 10 feet. The Harrison member, which has different thicknesses along the outcrop, contains many cobbles of silicified, fossiliferous limestone. A section measured about 100 yards north of the highway bridge follows:

		Ft.	In.
Pennsylvanian System			
Pottsville formation			
Sandstone, coarse, irregular 2-inch to 2-foot beds		15	0
Sandstone, coarse, massive		10	0
Sandstone, coarse, with ore nodules	*Harrison,* altitude 1,130 feet	0	7
Conglomerate, pebbles of white cherty, fossiliferous *Maxville* limestone up to 6 inches, some quartz pebbles intermixed	*Harrison,* altitude 1,130 feet	0	6
Conglomerate, well-rounded quartz pebbles up to 1 inch, mostly ¼ to ½ inch	*Harrison,* altitude 1,130 feet	0	10
Mississippian System			
Logan formation			
Sandstone, white, weathered; composed of small oolites		6	0

Across the railroad track from above section, the Harrison member is 3 feet 2 inches thick, only sparingly ferruginous, and composed in large part of cherty limestone cobbles, some of which are 8 inches in diameter. Fifty yards to the south the following section further illustrates the variability of the Harrison member over short distances:

		Ft.	In.
Pennsylvanian System			
Pottsville formation			
Sandstone, massive		20	0
Conglomerate, ¼ inch, white, rounded, quartz pebbles	*Harrison*	0	2
Ore, irregular, nodular and shaly	*Harrison*	1	3
Mississippian System			
Logan formation			
Shale, dark, iron-stained by the action of ground water		4	6

One mile southwest of Baddow Pass, in SW¼NW¼ Sec. 17, the conglomeratic character of the Harrison is maintained where it crops out along a road. Five-eighths mile northeast of Baddow Pass, in SE¼SW¼ Sec. 8, the Harrison member occurs as an impure ore along a road south of the railroad at an altitude of approximately 1,070 feet.

In the southeastern part of Richland Township the horizon of the Harrison member is largely concealed by the weathered masses of overlying massive Massillon sandstone which cover the slopes. In NE¼SE¼ Sec. 24, at the township line, loose pieces of cream-colored flint mark the position of the member at an altitude of 1,030 feet.

QUAKERTOWN COAL

STRATIGRAPHY AND EXTENT

The Quakertown coal extends across Ohio from Mahoning County to Scioto County. It is best developed in Jackson County, where it has been mined steadily since 1872.[1] It has been mined in a small way in

[1] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 81, 1927.

several townships in Holmes County, but with most success from an area in Monroe and Hardy townships, where it is generally known as the "Welcome" or "No. 1" coal.[1]

The position of the Quakertown coal in Holmes County is near the base of the Pottsville formation, in most places only 5 to 10 feet above the Pottsville-Logan contact, and 70 to 80 feet below the Lower Mercer limestone. The Quakertown member is commonly overlain and is at places replaced by the massive Massillon sandstone. In some localities the Quakertown stratum was never deposited, Pottsville deposition not beginning in these places until some time later than Quakertown time. The stratum is, therefore, patchy and discontinuous, and is cut off against buried Waverly hills.

In Holmes County, the Quakertown member is due above drainage in every township except Paint, Walnut Creek, and Clark, but is of little importance in any of the townships except Hardy and Monroe. The Quakertown coal ranges in thickness from a soot streak to 2 feet 8 inches. At most places it contains one or more irregular partings. It is everywhere a bituminous coal, with an occasional thin layer having canneloid tendency interbedded in the stratum.

The clay underlying the Quakertown coal is everywhere thin, impure, sandy, and without value.

Salt Creek Township.—Coal, believed to be Quakertown, was observed in the western part of Salt Creek Township. Outcrops at this horizon in other parts of the township are obscured by extensive glacial deposits in the valleys. Doubtless pockets of coal at this horizon are present beneath the drift but they are probably small and economically unimportant. Coal of fair quality has been removed from several small openings near the bottom of a small ravine in NW¼NE¼NW¼ Sec. 6, where the coal has the following character and structure:

		Ft.	In.
Clay shale, gray		2	0
Shale, hard, black		0	8
Coal, bony	*Quakertown,* altitude 1,020 feet	0	8
Coal, fair		2	0
Clay, siliceous, impure		2	0

Rapid change in thickness and character is characteristic of the Quakertown coal in Holmes County, as shown by the fact that 100 yards east of the section given above the coal passes into carbonaceous shale.

[1] The Quakertown, or "Welcome" coal, is correctly designated in the numbered series of Ohio coals as the No. 2. The true No. 1 coal, the Massillon or Sharon, mined near Massillon and in southern Ohio, is not found in Holmes County. The early report of M. C. Read (Geological Survey of Ohio, Vol. III, Pt. I, 1878, p. 548) identified this coal as No. 1, as did A. A. Wright (Mines of Holmes County: Geological Survey of Ohio, Vol. V, p. 819, 1884), although the latter noted the Sharon (No. 1) coal at Massillon lies 125 to 150 feet below the Lower Mercer limestone, while the lowest coal of Holmes County is usually only 80 feet below that limestone.

Prairie Township.—Coal or carbonaceous shale occurs in many places at the horizon of the Quarkertown in Prairie Township, especially in the southeastern and southern parts. In NE¼ Sec. 1, the Quarkertown coal is part of the lens, which has been described, that extends into Sec. 6 of Salt Creek Township. Interbedded coal, shale, and bony coal having a total thickness of more than 5 feet is well displayed in SE¼NE¼ Sec. 1 in a ravine just west of the larger ravine which debouches southward to the valley of Martins Creek (17-72, Appendix).

In the southeastern corner of Prairie Township the Quakertown coal is present. Just north of the road forks, on the north bank of Colliers Run, one-half mile south of Hammond School, 2 feet 2 inches of carbonaceous shale crops out at an elevation of approximately 970 feet, 67 feet below the Lower Mercer limestone and 100 feet below the Upper Mercer limestone. It is noteworthy that the bottom of the Pottsville in this region extends much lower stratigraphically than it does to the northeast, the interval between the Quakertown and the top of the Waverly, taken up mainly by sandy shale and shaly sandstone, being 81 feet 10 inches. One mile to the east, in the bank of Colliers Run, three-eighths of a mile northwest of the road forks at the Hardy-Prairie township line, the coal under discussion has the following character:

		Ft.	In.
Shale, gray		8	0
Coal, bony to canneloid	*Quakertown,* altitude 960 feet	0	7
Shale, coaly		0	3
Shale, gray		0	5
Coal, shaly		0	6
Shale, gray to dark, siliceous; varies in color laterally		6	0

The Quakertown coal has fair development in central northern Prairie Township, where it has been mined in a very small way in NE¼ NE¼ Sec. 34. The relationship of the coal to the bottom of the Pottsville, which is here stratigraphically very high, was observed along the road between NE Sec. 34 and SE Sec. 27, and is shown below:

	Ft.	In.
Pennsylvanian System		
Sandstone, light, shaly	3	6
Shale, carbonaceous	6	8
Coal, weathered, fair; not full thickness, *Quakertown*	1	2
Covered, some loose pieces of ore, *Harrison*	3	6
Mississippian System		
Sandstone, gray; harder and less fractured than in most places	5	0
Sandstone, shaly	25	0
Covered	13	0
Tea Run School road fork, altitude 959 feet.		

The Quakertown member seems to be absent from the rock section in western Prairie Township. In the southern portion, between Paint and Killbuck creeks, it is poorly developed. Where seen along the road in central Sec. 16, the member is 106 feet below the Bedford coal and 160 feet below the Putnam Hill limestone, and is represented by 1 foot of dark gray carbonaceous shale cropping out approximately 970 feet above tide (19-238).

Ripley Township.—No coal at the Quakertown horizon was seen in Ripley Township at the few outcrops of basal Pottsville rocks that are not obscured by glacial deposits. Thin strata of somewhat carbonaceous shale occur at about the Quakertown horizon, but these are so indefinite that they cannot be identified with certainty.

Washington Township.—The Quakertown member is generally poorly developed in Washington Township. In the southeastern part of the township carbonaceous material, tentatively identified as Quakertown, although the possibility must be considered that it is Bear Run, or even Vandusen, was observed along the Shreve road, one-half mile northeast of Nashville, just southwest of a road fork, as follows:

		Ft.	In.
Clay shale, with ore balls		3	0
Shale, carbonaceous, somewhat clay-like	*Quakertown?* altitude 1,150 ft.	1	4
Clay, impure to ganister		0	9
Shale, hard, black bone		0	4
Coal, fair, weathered		0	8
Shale, hard, carbonaceous bone		0	2
Clay, impure		0	3
Ganister, white, hard		4	0
Clay shale, sandy, impure		3	0

Knox Township.—The horizon of the Quakertown coal is generally occupied by sandstone, more rarely by shale, in Knox Township. A stratum of coal 6 inches thick, underlain by 3 feet 2 inches of impure clay, which in turn rests on Waverly sandstone observed along the road at an altitude of 1,160 feet in central Knox Township, one-fourth mile east of partial Sec. 13, may be Quakertown (31-319). This thin coal bed is 57 feet below the Lower Mercer limestone.

Cannel coal, which is probably Quakertown, was formerly mined in a ravine five-eighths mile south of Stone School and one-half mile southeast of the 1,400-foot knob, 1½ miles south of Nashville. The coal is reported to be from 28 to 30 inches in thickness, with a 1 to 2 inch "mud seam" near the center of the bed. The deposit is probably only that of a small basin, as 200 yards north of the old mine the same horizon is represented by 30 inches of black, carbonaceous shale with many cannel coal streaks. The coal lies 74 feet below the base of the Upper Mercer black flint and apparently not far above the base of the Pottsville which is obscure at this locality (25-396). The interval to the Upper Mercer flint is unusually small for Quakertown, and this local lens of cannel coal may be of later age, possibly Bear Run or Vandusen.

Monroe Township.—The most important area of Quakertown coal in Holmes County is located in Monroe Township. Many small mines have operated in the bed in the northeastern part of the township, near Paint Valley, and in the southern part of the township, chiefly west of Welcome, where the coal is locally known as the "Welcome," or "No. 1" coal. The coal is in basins or pockets, which are lower than the higher parts of the buried Waverly hills, so that the bed is at many places abruptly cut off against the buried Waverly sandstone hills. South and southeast of Paint Valley, in the northeastern part of the township, are several abandoned mines which operated in a bed believed to be Quakertown. No sections are now exposed for measurement or to show relation to other members.

The coal has been mined in the southwestern part of the township by Clayton Rizer and Walter Lewis on the farm of John Armstrong, from an opening in a ravine three-fourths of a mile west of Birds School. The coal is 2 feet 4 inches in thickness and has several partings. The details of the bed and the strata above and below are shown in 36-313, Appendix.

The Quakertown coal has been mined from the ravine south of Birds School, where it has a fair thickness. This coal has been mined from several openings, not far above stream level, on the southwest side of Shrimplin Creek Valley, about 1 mile west of Welcome. The coal here rests almost directly upon the Waverly sandstone. On the northeast side of the stream the Waverly is higher, and no Quakertown coal was deposited. It is interesting to note that the Quakertown in this area has an altitude of 990 feet, but 1 mile to the northwest, the Waverly-Pottsville contact is 1,070 feet above tide. The coal in the Welcome field is of good quality, burning to a soft, powdery, reddish ash, which is small in amount. The coal makes a satisfactory fuel for domestic use. (For analysis see under "Economic Value.") The character of the coal and the structure of the bed in the local mine of A. R. Mackey, located just southwest of Shrimplin Creek, 1 mile west-northwest of Welcome, is recorded as follows:

		Ft.	In.
Shale		8	0
Shale, carbonaceous	Quakertown, altitude 990 ft.	0	10
Coal, good		1	1
Shale, dark, coaly, clay-like		0	1½
Coal, bony		0	½
Coal, good		1	7
Clay, gray, plastic		1	6
Shale, gray, with occasional 2- to 4-inch lenses of bone shale		1	7
Coal, bony, irregular		0	5
Sandstone, massive		5	0
Shale, slightly carbonaceous		0	8
Sandstone, massive		5	0

The irregular structure of the coal is especially evident in the mine of Oberholtzer Brothers, on the land of Howard Bell, one-fourth mile southwest of the Mackey mine. Here the floor is uneven, and high places in the floor reduce the thickness of the bed. The uneven roof shows that erosion has removed part of the top of the bed. At such "cut-offs" the coal may be reduced to a thickness of 1 foot or even less. A section that is representative of the bed in the Oberholtzer mine follows:

		Ft.	In.
Shale, dark gray, siliceous		2	4
Coal, good		0	8½
Coal, bony		0	2
Shale, dark, carbonaceous	*Quakertown,*	0	⅜
Coal, bony	altitude	0	2
Coal, good	990 feet	1	4
Coal, bony		0	6
Clay, impure, slickensided		1	6
Sandstone, white, clay-bonded			

The Quakertown coal extends with fair thickness southward from Welcome to the Killbuck-Monroe township line. One and one-half miles south of Welcome, and 100 yards north of NE¼NE¼ Sec. 3, Killbuck Township, the coal has been mined for local use on the farm of H. W. Moore. The following section, measured in a ravine and at the mine mouth, is illustrative of the general character of the bed:

		Ft.	In.
Pennsylvanian system			
Sandstone, massive		10	0
Sandstone, conglomeratic, a few ¼-inch quartz pebbles		0	10
Sandstone, coarse, massive		7	0
Shale, hard, black		1	3
Coal, good	*Quakertown,*	0	8½
Shale, carbonaceous	altitude	0	1½
Coal, good	1,000 ft.	1	3
Coal, bony		0	5
Shale, gray		2	6
Covered		6	2
Mississippian system			
Sandstone, thin-bedded			

The erratic character of the member under discussion is shown by the following section, measured 25 feet inside the mouth of the mine on the Moore property, where the coal has a greatly increased thickness, which, however, persists only for about 25 feet:

		Ft.	In.
Shale, gray, clay-like		1	2
Coal, good		1	1
Clay, very sandy		1	4
Sandstone, white, hard	*Quakertown*	0	4
Coal, good		0	7
Shale, soft, coaly		0	2½
Coal, good		1	2½

On the east side of the ravine, opposite the Moore mine, the Quakertown coal is absent, the Waverly sandstone rising at least 12 feet and probably much higher than the coal.

Although no outcrops of the Quakertown members were observed in Monroe Township northeast of Shrimplin Creek, the coal was penetrated under deep cover in drilling a water well on the property of Homer Doty, 1 mile east-northeast of Welcome (40-280, Appendix).

Little is known of the Quakertown coal in the northern part of the township because of drift concealing the horizon. It is not improbable that lenses of coal of minable thickness may be present south of Paint Creek, as indicated by a report of Read[1] in which it is stated that at "Smith's bank in the northern [northeastern?] part of Monroe Township, it reaches a thickness of four feet, is a true block coal, of fine quality, and reasonably free from sulphur."

Hardy Township.—The Quakertown coal has been mined in a small way from several openings in Hardy Township, but the coal proved to be so erratic in thickness and quality that its exploitation has never been very successful. The member may be more generally found where due in Hardy Township than in any other in Holmes County because the Pottsville strata extend low stratigraphically in this township. The Quakertown coal, where seen in the northeast part of Hardy Township, is very thin. The following section, measured along a road three-eighths mile east of Honey Run School and three-fourths mile west of NW¼NW¼ partial Sec. 6, is representative:

	Ft.	In.
Pennsylvanian system		
Clay shale	5	0
Coal, good, *Quakertown*	0	7
Clay, dark	0	6
Clay, light, plastic	2	0
Shale, and covered	14	6
Mississippian system		
Sandstone	4	0
Sandstone; and drift covered	47	0
Road forks, altitude 858 feet		

The Quakertown coal was formerly mined from several small openings, now fallen in, in a ravine one-fourth mile north of Sapps Run, 1¼ miles northwest of the Courthouse in Millersburg. Although at some places under cover the thickness may have been satisfactory for mining, probably the average thickness is no more than shown by the following measurements taken at the mouth of one of the old mines:

[1] Read, M. C., Report on the Geology of Holmes County: Geol. Survey Ohio, Vol. 3, Pt. 1, p. 548, 1878.

		Ft.	In.
Sandstone, massive, *Massillon*		21	0
Coal, good	*Quakertown,* altitude 900 feet	0	8
Shale, dark, carbonaceous to coaly		0	1½
Coal, good		1	2

In the southeastern part of Hardy Township, the Quakertown member was formerly mined on the farm of Charles Strait, in SW¼ partial Sec. 25. Mr. Strait reported that the coal is about 2 feet in thickness. On the other side of the ridge from the old Strait mine, a small mine has been opened on the farm of Edward Mitten, on the south side of the valley of Sand Run, in NE¼NW¼ Sec. 24, where the coal has the following thickness and structure:

		Ft.	In.
Sandstone, coarse, *Massillon*		50	0
Shale, carbonaceous	*Quakertown,* altitude 920 feet	0	6
Coal, bony		0	5
Coal, good		2	7
Clay, sandy; probably thin.			

The erratic behavior of the member under discussion is shown by a change to carbonaceous shale only five-eighths mile east, where the following section is exposed in the banks of Sand Run in NE¼NE¼ Sec. 24 at the Hardy-Berlin township line:

	Ft.	In.
Sandstone, coarse, massive, *Massillon*	15	0
Shale, carbonaceous to coaly, *Quakertown* horizon, altitude 940 ft.	11	5
Ore, impure, dark, carbonaceous; somewhat sandy	0	6
Clay shale, dark gray; with some ore nodules	3	2
Sandstone, clay-bonded; with plant fossils	2	0

Berlin Township.— The Quakertown horizon is under cover in Berlin Township except in a very small area in NW Sec. 23 in the valley of Sand Run, where several feet of carbonaceous shale crops out. Although it is possible that Quakertown coal of minable thickness and quality may exist under cover, no subsurface data are at hand.

The Quakertown coal is under cover in Walnut Creek and Clark townships.

Mechanic Township.—The Quakertown coal is thin and unimportant in Mechanic Township. The position and character of the member in the northeastern part of the township in NE¼ Sec. 10 is well shown in 124-81, Appendix.

In the central northern part of Mechanic Township, Quakertown coal, represented by coaly shale 1 foot in thickness, was observed at an elevation of 910 feet along a road 1 mile northeast of Grade, three-eighths mile south of SW¼ Sec. 24, Hardy Township (128-40).

Killbuck Township.—The Quakertown coal is thin and erratic in Killbuck Township, and no successful efforts have been made to mine the member. The northern part of Killbuck Township adjoins the field of Quakertown coal in Monroe and Hardy townships which has supported some small mines, and it is possible that in this part of the township small areas of the coal may reach a thickness great enough for mining in a small way. On the farm of J. W. Phillips, in a ravine in NW¼ SW¼ Sec. 4, Quakertown coal of a bony canneloid character is at least 1 foot 6 inches in thickness on the outcrop (140-294 Appendix), but when a mine was opened, only 8 inches of fair quality cannel coal was found and mining attempts were abandoned.

In Sec. 1, in the central northern part of Killbuck Township, the coal under discussion has a thickness of 4 inches along a road, at an altitude of 960 feet (142-285). The member was not observed in the western part of the township.

A small opening has been driven in search of Quakertown coal in NE¼ Sec. 15, 1 mile southeast of Killbuck village, by Brice Leguillon, but no coal was produced. A section of the strata exposed along the road nearby is given as 147-273, Appendix.

Richland Township.—The Quakertown coal is thin and discontinuous in Richland Township. It is at many places replaced by the massive Massillon sandstone, especially in the northeastern part of the township. In SW¼NW¼ Sec. 4, near the road fork 2 miles east of Glenmont, the Quakertown member consists of 2 feet of bony coal and dark shale (157-268, 269, Appendix).

In the northwestern part of Richland Township, a small opening has been driven into the Quakertown member on the farm of Frank Eaton, 1 mile east of Greer, in SE¼NW¼ Sec. 5. Very little coal was taken out, and the mine has now fallen in. No data could be secured as to the thickness of the member here, but it is believed to be thin.

The horizon of the Quakertown member is due along the valley sides in the southern part of Richland Township, but no more than a very few inches of coaly material was seen at this horizon.

ECONOMIC VALUE

The Quakertown coal is nowhere of sufficient thickness or continuity for mining on an extensive scale. The most promising area, from which some coal has already been removed, is in the southern half of Monroe Township, the southern half of Hardy Township and the contiguous parts of Knox, Richland, Killbuck, and Mechanic townships. In this area, especially near Welcome, small mines have recently operated, and sufficient coal is still present for local household use for many years. Before starting mining operations on anything but a small way, careful test drilling to determine the area and thickness of Quakertown coal available should be carried on, as the bed varies rapidly in thickness and may disappear in short distances.

The thickness of the Quakertown coal in this area ranges from 1 foot 6 inches to 2 feet 6 inches. One or more partings of clay shale cut the bed into benches, and add to the ash content of the coal unless they are carefully removed. The partings are very irregular as to presence and thickness. The roof is at most places a sandy shale, but at some places is sandstone. The roof is typically irregular, and "cut-outs," "horsebacks," and "rolls" are common enough everywhere in the county to interfere with satisfactory mining.

The coal is moderately strong, and withstands handling well. It burns freely and openly. Although mainly a bright banded coal, a few thin streaks of cannel coal are present at some places. It has a good reputation for local heating purposes, as the calorific value is above average. The ash content is not excessively high, provided the shale partings are carefully removed in mining. The ash fuses at a high temperature and therefore clinkers little. The following analysis is representative:[1]

Sample of Quakertown coal taken in 1928 by W. S. Glock and L. O. Naffziger from mine of A. R. Mackey 1 mile northwest of Welcome in the southwest part of central Monroe Township, Holmes County. Analysis by D. J. Demorest.

		Ft.	In.
Shale, gray, roof.			
Coal, shaly, rejected	*Quakertown*	0	2
Coal, sampled	*Quakertown*	0	9
Shale, gray, soft, rejected	*Quakertown*	0	1
Coal, sampled	*Quakertown*	1	5¼
Shale, gray, floor.			

Proximate analysis

	As received	Moisture free
Moisture	6.43	0.00
Volatile matter	40.69	43.48
Fixed carbon	46.84	50.06
Ash	6.04	6.46
	100.00	100.00
Sulphur	2.48	2.65

Air drying loss 1.80 per cent

		As received	Moisture free
Heating value	Calories	7,024	7,506
	B. t. u.	12,643	13,511
Fusion of ash	Incipient	2,152°F.	
	Complete	2,374°F.	

MASSILLON SANDSTONE

STRATIGRAPHY AND EXTENT

The Massillon sandstone is the lowest of the discontinuous Coal Measures sandstones which occur in Holmes County, as the Pottsville in the county does not include the lower Sharon sandstone or conglomerate found in some parts of Ohio. The position of the Massillon member is

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, pp. 19-20, 1929.

above the Quakertown (No. 2) coal, which it replaces locally. It may extend upward to the next higher coal, the Bear Run, or more commonly it replaces the Bear Run member and extends to the next coal, the Vandusen. In may extend even higher. In Ohio, the Massillon sandstone is found in all counties in which lower Pottsville strata crop out, and it is present under cover to the eastward, down the dip, as the "Salt Sand" of the oil driller. It is named from prominent outcrops near Massillon, in Stark County, where it has been quarried in the past.

In Holmes County the Massillon sandstone is one of the most economically valuable rock units, and has been extensively quarried for a variety of purposes. (See under "Economic Value.") It crops out in every township except Walnut Creek, but is best developed in the southern row of townships, where at places it occurs as bold cliffs, from which large blocks have separated and crept for considerable distances below the position of the member. In the northern part of the county the horizon is more commonly occupied by shale, or, if sandstone is present, it does not reach the thickness usually found in the southern part.

The member where present in Holmes County generally rests upon the Quakertown coal, at places with a few feet of shale intervening. It locally replaces the coal and lies directly upon the Harrison ore and conglomerate or upon the Mississippian strata. The top of the sandstone may reach the Vandusen horizon or even the position of the Lower Mercer coal. In such occurrence the sandstone is commonly divided into two parts, an "upper" and "lower," with a few feet of shale between, in which in many places is included carbonaceous material representing the Vandusen coal. The average thickness of the Massillon sandstone, determined from 20 measurements, is 47 feet 7 inches. Its thickness ranges from a paper-thin layer to 91 feet. In western central Richland Township the overlying Homewood sandstone, which properly belongs above the Tionesta horizon, lies very close to the top of the expanded Massillon; and the Homewood in turn is overlain by a massive sandstone, the proper position of which is above the Lower Kittanning coal, which rests upon, or almost upon, the Homewood. In this locality, therefore, almost the entire rock section of Pottsville and lower Allegheny strata is composed of sandstone. A similar condition exists to the south, in Monroe Township, Coshocton County.

The Massillon is a coarse, generally thick-bedded to massive sandstone. It is locally cross-bedded. Layers of quartz pebbles up to one-half inch in diameter may occur in the basal few feet, or rarely even higher. The sand grains are mainly quartz, subangular to subround, cemented by iron oxide and clay matter in varying proportions. It is gray under heavy cover but where seen on the outcrop it is commonly buff, golden, brown, or more rarely reddish purple. The porosity and permeability vary, but in general the rock freely transmits water and springs are common at its base. Under cover, it is an important source of water in wells which penetrate it.

Salt Creek Township.—Although some thin sandstone strata are present at the Massillon horizon in parts of Salt Creek Township no definite, massive sandstone, which is characteristic of the Massillon member at many other places in the county, is here developed.

Prairie Township.—The horizon of the Massillon member is occupied by shale, or locally by shaly sandstone, in Prairie Township, except in the central southern part, where more than 14 feet of massive sandstone is exposed along a road in E½ Sec. 16 (19-238, Appendix).

Ripley Township.—Strata at the Massillon horizon are generally concealed by drift in Ripley Township, but few indications of well-developed sandstone at this position were noted in the few unsatisfactory outcrops observed. Drill records indicate that the Massillon sandstone may be present in the southwestern part of the township, near Nashville.

Washington Township.—Sandstone identified as Massillon was observed near the base of the Pottsville series at several places in Washington Township. In the central part, in central Sec. 3, 28 feet of coarse sandstone, with irregular lenses of conglomerate having a thickness of as much as 6 inches, overlies the Harrison member. Sandstone is probably present south of this location. The Massillon member is present at the top of the first ridge east of Loudonville, as shown by the following measurements along the state road in SE¼NE¼ Sec. 6:

	Ft.	In.
Pennsylvanian System		
Sandstone, massive; and covered; *Massillon*	17	6
Conglomerate, *Harrison*, altitude 1,160 feet	2	6
Mississippian System		
Sandstone and covered	30	0

Massillon sandstone possibly underlies the high land west of Crab Run in the central southern part of the township, but no data are at hand from this locality. In the southeastern part of the township, 2 miles north of Nashville, it is reported that 80 feet of Massillon sandstone was penetrated in drilling.

Knox Township.—Massillon sandstone is present in at least part of Knox Township, but no considerable continuous thickness appears in the section except in the southern part of the township. Two miles northwest of Glenmont there is indication of as much as 80 feet of sandstone but outcrops are not clear enough to permit detailed observations.

Monroe Township.—The character of the Massillon sandstone is not known in the northern part of Monroe Township because of the drift covering. It is present, but erratic in thickness, in the central western part of the township, ranging in thickness from a few feet to 30 feet or more, within short distances. In the southern part, 1½ miles southwest of Welcome, Massillon sandstone, although poorly exposed, appears to have a thickness of at least 40 feet. In a well drilled 1 mile east-north-east of Welcome 50 feet of Massillon sandstone is reported (40-280, Appendix). In the southeastern corner of the township shale occupies the Massillon horizon.

Hardy Township.—Sandstone of greater or less thickness is generally present in the lower part of the Pottsville column in Hardy Township, although clear exposures are not common because of the drift covering the lower valley slopes. The base of the sandstone is just over the Quakertown coal, and may continue upward to a position of about the Lower Mercer coal, thus occupying the place of the Bear Run coal and at places that of the Vandusen member. About a mile west of Millersburg, north of Sapps Run, sandstone above the Quakertown coal has a thickness of at least 40 feet. This thickness appears to be maintained for at least 2 miles to the northwest. Southeast of Millersburg the Massillon member is thinner; a thickness of 20 feet was measured in SW¼SE¼ Sec. 20 (59-9, Appendix).

Berlin Township.—The horizon of the Massillon sandstone is due only in the extreme southwestern part of Berlin Township and along Doughty Creek near the Mechanic Township line. A few feet of sandstone, correlated as the upper part of the Massillon, is present at both these localities at drainage level.

The member is below drainage in Walnut Creek Township.

Clark Township.—The horizon of the upper part of the Massillon sandstone is above drainage in Clark Township only in the northwest corner, near the level of Doughty Creek, and in the southwest corner, near the level of Mill Creek. In NW¼ Sec. 5, from 5 to 20 feet of coarse, cross-bedded sandstone is exposed in the bed and banks of a tributary to Doughty Creek. The full thickness of the member is exposed less than a mile to the west in Mechanic Township, in the gorge of Doughty Creek.

In W½ Sec. 25, coarse, massive Massillon sandstone crops out from the level of Mill Creek to a position 50 feet higher on the valley sides. The top of the sandstone lies 20 feet below the Lower Mercer limestone along the road east of the stream (109-186, Appendix).

Mechanic Township.—The Massillon sandstone is prominently developed in Mechanic Township. It crops out along the sides of the valley of Doughty Creek and along those of its tributaries in the eastern, central, and southern parts of the township, and along the sides of the valleys of Killbuck Creek and of Sand Run in the northwestern part. The finest exposures are in the gorge of Doughty Creek between Becks Mills and the northeastern corner of the township.

In the upper part of the gorge of Doughty Creek, in NE¼ Sec. 1, 40 feet of coarse, massive sandstone is exposed above the stream. One mile downstream (south) the base of the Massillon member appears above stream level, with the Quakertown coal under it. Sandstone, with a few shale layers, extends for 113 feet above the Quakertown member to within 4 feet of the base of the Lower Mercer limestone on the west side of the valley; but on the east side of the valley, sandstone extends only to within 26 feet of the Lower Mercer limestone, the interval being occupied by shale and by the Lower Mercer and Flint Ridge coal horizons. The top of the Massillon is taken as 75 feet above the Quakertown coal, but this designation is recognized as being more or less arbitrary (124-81, Appendix).

In the valley of Military Run, west of Becks Mills, sandstone is present at the Massillon horizon, but it is finer grained and more broken by shale layers than in the Doughty Creek gorge. West of Military Run, 2½ miles north of the county line, the Massillon sandstone is more persistent, and from 40 to 45 feet of coarse sandstone in 1- to 3-foot beds appears. Farther west, in the valley of Bucks Run, 36 feet of the upper part of the member is exposed along a road just east of Bucks Run 2¼ miles north of the county line (132-125).

Along a road one-half mile north of Doughty Creek and 1 mile northeast of Clark, the full thickness of the Massillon member was not seen, but the upper part is well exposed. A section measured here is as follows:

	Ft.	In.
Sandstone, not well exposed	45	0
Clay and covered, *Vandusen* horizon?	2	0
Sandstone, medium-grained	10	6
Ore, sandy	0	6
Sandstone, coarse; massive to 3-inch beds, *Massillon*	28	4
Road forks, altitude 895 feet.		

Northwest of Clark, in the western part of Mechanic Township, the Massillon is well developed as a massive, coarse sandstone. One-half mile west of Stony Point School, in SW¼SE¼ Sec. 12, the sandstone is 44 feet in thickness (136-5).

In the northwestern corner of the township, along the east valley wall of Killbuck Creek in southern Sec. 2, the Massillon member is very coarse and massive, and is at least 50 feet thick. Large blocks weather loose and slowly creep down the slopes. In central Sec. 2 the sandstone is from 20 to 25 feet in thickness. To the east the Massillon member is under cover in much of Sec. 1, but just east of Sec. 1 the sandstone crops out prominently in the valley of a tributary to Sand Run. In a ravine and along a road to the east, starting 1 mile east of Sec. 1 and one-half mile south of the Hardy-Mechanic township line, 49 feet of sandstone lies directly upon the Quakertown coal (128-40).

Killbuck Township.—The Massillon sandstone has excellent development over most of Killbuck Township. It crops out well above drainage along the major valleys, and large blocks which have weathered loose and are creeping downward are conspicuous on the hillsides. The sandstone thickens at places to include the interval from the base or near the base of the Pottsville to almost the base of the Lower Mercer limestone, in such places occupying the horizon of the Bear Run and Vandusen coals and even that of the Lower Mercer coal. Generally thin shale and carbonaceous material, probably representing the Vandusen coal horizon, separates the "lower" from the "upper" sandstone, which seems to indicate that the "upper" sandstone is not strictly Massillon in age.[1] This "double" character of the member is well shown in a ravine along the road in SE¼SE¼SW¼ Sec. 8 (148-31, Appendix).

Eastward, toward Killbuck village, the sandstone becomes thinner, and the "upper" sandstone member is replaced by shale. Along the road one-half mile southeast of Killbuck, in SE¼NE¼ Sec. 15, the Massillon member is 28 feet in thickness and is underlain by Quakertown clay and coal (147-273).

North and northeast of Killbuck village the sandstone crops out prominently in Secs. 4 and 5. In NW¼SW¼ Sec. 4, north of the road, a quarry was operated by Charles Uhl on the J. W. Phillips farm until about 1910 (140-294).

In the northwestern and southwestern parts of Killbuck Township the Massillon member varies in thickness. In Sec. 8 it reaches at least 50 feet in places. In ravines in Sec. 23 the sandstone crops out prominently, but neither top nor bottom of the member is well exposed because of the slumping on the hillsides. In NW¼SE¼ Sec. 23, Massillon sandstone extends upward to within 8 feet of the base of the Lower Mercer limestone.

In the southern part of the township in SE¼SE¼ Sec. 25, the Massillon sandstone has been quarried for grindstones and building stone by Reno F. Mussey of Elyria, Ohio. The sandstone has a maximum thickness of 62 feet, but the upper portion is weathered. The stone is buff, coarse-grained, and massive. Moderate cross-bedding is exhibited in parts of the member.

The sandstone in the southeastern part of the township exhibits at places the development of "upper" and "lower" divisions, resulting in a total thickness of more than 50 feet. In a ravine and along a road in SW¼NE¼ Sec. 18, the sandstone is 70 feet in thickness, the lower, more massive 30 feet forming a falls in the small stream (151-74, Appendix).

Richland Township.—The Massillon sandstone is very well developed over most of Richland Township. The rock has been extensively quarried for building stone and just west of the township one quarry for glass sand has been operated. The Briar Hill sandstone used for building in Ohio and many other states is Massillon sandstone, in large part from this township. The sandstone at many places crops out as ledges along the valley

[1] *cf.* Stout, W., Geology of Muskingum County: Geol. Survey Ohio Bull. 21, p. 60, 1918.

sides, and large blocks break loose and creep down the hillsides below. The stratigraphic position of the Massillon sandstone is between the Quakertown coal and the Bear Run coal, but in this township it frequently rests upon the Logan strata, and sandstone may continue upward almost to the base of the Lower Mercer limestone, replacing the Bear Run and Vandusen coals and even the Lower Mercer coal. In such occurrences the expanded member is called Massillon, although it is realized that the whole thickness includes an upper part that is not strictly such. In Mechanic Township the sandstone, where thick, is at many localities separated into an "upper" and "lower" division by the intervention of a few feet of shale which includes some carbonaceous material, but such a division was not observed in Richland Township.

In the northeastern part of the township in Sec. 4, the sandstone is as much as 80 feet in thickness. The lower part is the more massive, the upper being more or less irregularly and thinly bedded. The Briar Hill Stone Company has extensively quarried the Massillon sandstone in SE¼SW¼ Sec. 5, where are also located their mill and storage yard. The Massillon member in the quarry has a thickness of about 45 feet. The stone is gray to buff, but darker colors also occur. A few small pieces of organic material, most of them one-eighth to one-fourth inch in size, are present in some beds. The grain is medium to coarse; the mineral grains are mainly quartz, cemented with silica, clay, and iron oxide.

West of Glenmont the sandstone has exceptional thickness where it has been quarried on the S. W. Augsberger farm in NW¼ Sec. 2. Drilling indicates that the sandstone has a maximum thickness of 91 feet. It is cross-bedded in part, and the lower 10 feet is reported to have bands of coal interbedded. In E Sec. 3 along a road the Massillon member is 61 feet in thickness, 38 feet of strata, mainly shale, intervening between the top of the sandstone and the overlying Lower Mercer limestone (158-359, Appendix).

In the central western part of the township, in S Sec. 8 and N Sec. 13, sandstone occupies almost the whole interval from the Harrison ore to the Bedford clay (163-362, Appendix).

Less than a mile to the southwest the lower part of the Massillon member is well exposed in the Pennsylvania Railroad cut at Baddow Pass in SE¼NE¼ Sec. 14, where it directly overlies the Harrison ore and conglomerate. The basal 20 feet of the sandstone member here exposed is coarse, ranging from massive to irregularly stratified sandstone in beds 2 inches to 2 feet in thickness.

In the northwest corner of the township the Massillon sandstone is exposed near the hilltops in Sec. 5, the full thickness not being preserved. To the south, the sandstone was formerly quarried for glass sand just west of Holmes County in SE¼NE¼ Sec. 11, Jefferson Township, Knox

County. The thickness of the sandstone worked in the quarry is 46 feet. Here it is white, coarse, cross-bedded to massive, breaking and weathering along the cross-bedding. The rock is composed of coarse, subangular quartz grains, cemented by clay and iron oxide. The rock from the quarry was prepared at a plant at the foot of the hillslope by crushing in a gyratory crusher, screening, and washing. In later years the sandstone from this quarry has been crushed and marketed for steel molding sand.

The sandstone member is conspicuous in the southwestern part of Richland Township. Its character and relation to the Harrison member are shown by the following data observed along a road in SW¼NW¼ Sec. 17:

	Ft.	In.
Clay and covered	3	0
Shale, sandy; and covered	19	0
Sandstone, coarse, massive, *Massillon*	38	6
Covered, a few pieces of conglomerate and ore, *Harrison*, altitude 1,140 feet	5	0

Just west of Sec. 25, in the southwestern corner of the township and county, one-half mile south of Brinkhaven, in SE¼ Sec. 21, Union Township, Knox County, the Massillon sandstone is 42 feet in thickness where exposed along a road. Its base is close to or rests upon the Logan strata. South of Richland Township, the Massillon sandstone is well developed in Tiverton Township, Coshocton County. It has been quarried extensively near Cavallo, in the central western part of that township.

The Massillon sandstone is of good thickness and of massive character in the southern part of Richland Township, where it crops out conspicuously, and where large, loose blocks of the member mantle the hillsides below the outcrop. The base of the Massillon is concealed by weathered debris, but the sandstone appears, especially in the southeastern part, to reach a thickness of more than 60 feet.

ECONOMIC VALUE

Ohio produces well over half of the sandstone used for building in the United States. The Massillon sandstone of Holmes County is an important contributor to this production. The member is therefore an important geologic resource of Holmes County. In pioneer days it furnished stone for building from many of the townships, and many commercial quarries have operated, principally in Killbuck and Richland townships. Present quarrying operations are largely confined to the latter township. Large reserves of the stone are present in these and other townships. Bownocker,[1] writing in 1915, noted the importance of brown phase of the member:

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[1] Bownocker, J. A., Building Stones of Ohio: Geol. Survey Ohio Bull. 18, pp. 143-144, 1915.

"Holmes County has been the one important source of brown sandstone in Ohio. It was found in place as pockets and as loose blocks in the hills east and south of Millersburg and on the hills just west of Killbuck. In the latter quarry a ledge of 35 feet was worked but not more than one-third had the brown color. The color varied from uniform dark brown through various shades of lighter brown and striped to buff or gray. The grain was coarse and cross-bedding was prominent. The stone from this and other quarries was shipped in large blocks and sawed to desired sizes where used. The best of this brown stone had a wide market which extended east to Buffalo, south to Birmingham, and west to St. Louis. It may be seen in many residences and business blocks in Ohio. Good examples are shown in Columbus in the Commerce Building, Board of Trade, Young Men's Christian Association, and Southern Hotel. Little or no quarrying of brown stone has been done in Holmes County since 1900.

"Brown sandstone has been quarried on a small scale in an irregular way along the Mohican and Walhonding rivers, and especially near the station Cavallo, where a ledge of 20 feet was worked, the lower 10 of which varied in color from light to dark brown. The stone is coarse and soft and appears to darken rapidly on exposure. The quantity, however, is small and can be secured only by removing the overlying stone. From what has been said it is clear that brown sandstone occurs only in pockets, that the quantity is small and the color uncertain. No deposit of this stone is known in Ohio that can be worked with profit.

"Holmes County contains much light-colored sandstone that is suitable for building purposes. This is well exposed along Killbuck Creek and its tributaries and has been worked at numerous places. The stone is massive, coarse-grained and usually of buff or gray color."

Since Bownocker's study the golden brown phase of the Massillon sandstone has been quarried extensively and marketed widely throughout the country. The largest producer has been the Briar Hill Stone Company, of Glenmont, which markets the stone under the trade-mark "Briar Hill Golden Tone Sandstone." The stone produced is golden buff, variegated in either light or dark shades; or "Variegated" which consists of banded, mottled, speckled, and clouded markings in a variety of patterns and combinations. The quarries are located near Glenmont, and the strata there have been described under Richland Township. The company also operates quarries in the Massillon member in Tiverton Township, Coshocton County, the large blocks being brought to Glenmont for sawing and finishing.

Churches, banks, public buildings, and residences in Ohio, Michigan, California, New York, Massachusetts, Washington, D. C., Rhode Island, Pennsylvania, and many other states have used this sandstone in their construction. A noteworthy group built of Massillon sandstone from Holmes County is Sterling Library, Payne Whitney Gymnasium, and Harkness Memorial Quadrangle of Yale University, New Haven, Connecticut.

Of late years methods have been perfected for making split-face ashlar veneer for facing walls of residences, churches, and other buildings. The color range and moderate costs due to large-scale production have made this stone popular for facing houses in the medium price ranges, as well as in more pretentious buildings.

The stone is medium- to coarse-grained and is composed mostly of quartz. The cementing materials are iron oxide, clay minerals, and secondary silica. An analysis furnished by the Briar Hill Stone Company is as follows:

Silicon dioxide	95.00
Aluminum oxide	2.75
Iron oxide	0.6
Calcium oxide	0.3
Magnesium oxide	0.25

Tests made for the Briar Hill Stone Company show that the stone has an absorption of less than 6 percent by volume. The crushing strength ranges from 4,000 to 6,000 pounds per square inch, 5,000 being about average. The stone weighs 150 pounds per cubic foot.

In addition to its use for building stone, the Massillon sandstone has been quarried for grindstones by Reno F. Mussey of Elyria, in Sec. 25, Killbuck Township.

The Massillon sandstone has been quarried for glass sand very near the Holmes-Knox county line, in E Sec. 11, Jefferson Township, Knox County. In the quarry 46 feet of white, coarse, cross-bedded to massive sandstone was exposed. The rock was crushed at a plant below the quarry. No analyses of the material are at hand, but after screening and washing the product is reported to have been over 99 percent silicon dioxide. No attempts to use the Massillon for glass sand are known from Holmes County, but it is possible that with suitable mechanical and chemical processing a satisfactory glass sand could be produced.

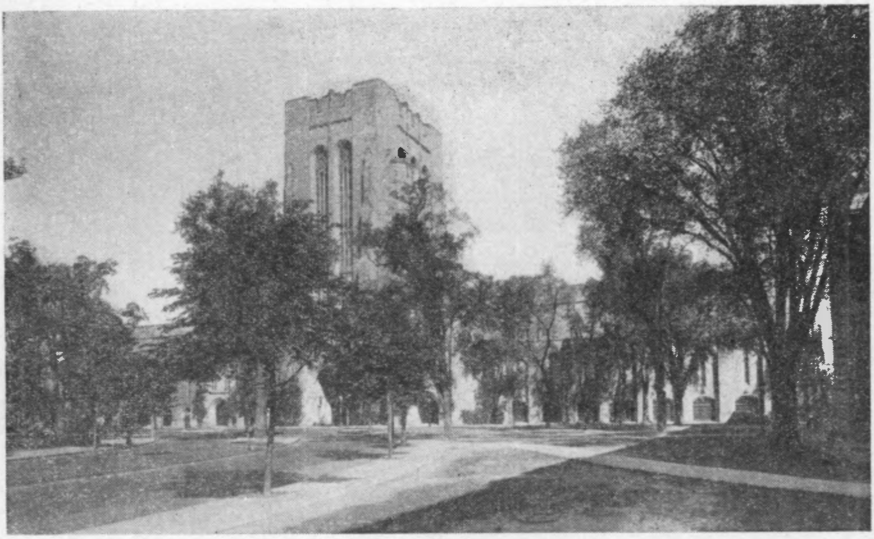
The Massillon sandstone from the quarry just mentioned has also been used for steel molding sand. Much of the member in Holmes County offers possibilities for this use.

BEAR RUN COAL

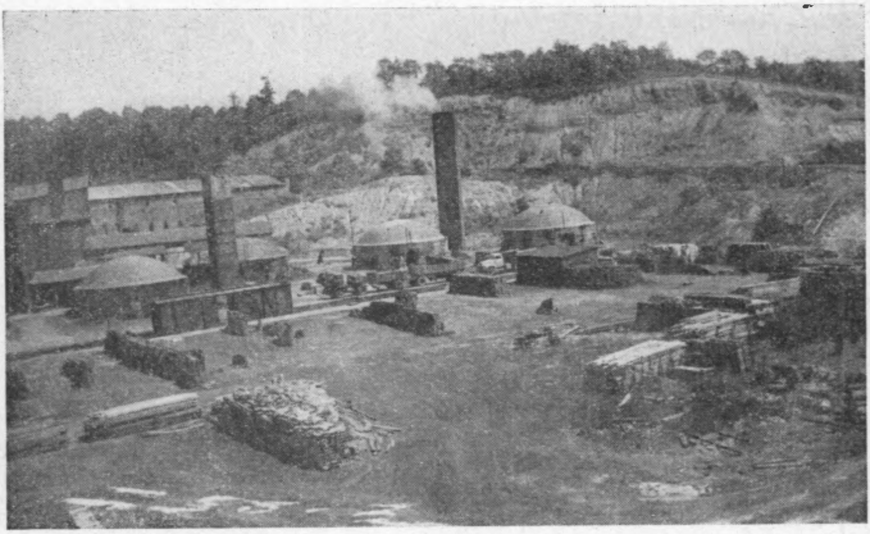
In the Pottsville formation of rocks in Ohio a thin coal bed lying from 15 to 30 feet above the Quakertown coal is present in many places. It is of minor importance as a source of fuel in the valley of Bear Run in Bloom Township, Scioto County, from which locality the name is derived. Elsewhere in the State it is a very thin coal stratum or, more commonly, carbonaceous shale.[1] In Holmes County a few inches of shaly coal or carbonaceous shale lying from 8 to 15 feet above the Quakertown coal is identified as Bear Run. It is replaced by the massive Massillon sandstone at many outcrops. The member is of no value for fuel purposes. The underlying clay, where present, is generally very siliceous and im-

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, p. 20, 1929.

PLATE IV



A.—Payne Whitney Gymnasium, Yale University, New Haven, Connecticut, built of Briar Hill (Massillon) sandstone.



B.—View of plant and shale pit of General Clay Products Company, SE ¼ Sec. 25, Clark Township, ½ mile northeast of Baltic.

pure, except at one locality, 1 mile north-northeast of Welcome, in Monroe Township.

The Bear Run horizon in Salt Creek Township may be represented by 2 feet of carbonaceous shale 8 feet above the Quakertown coal in NE¼ NW¼ Sec. 6. Nearby in SE¼NE¼ Sec. 1, Prairie Township, similar shale appears at the same horizon (17-72, Appendix). The member was not observed elsewhere in these townships.

One or two indications of carbonaceous shale at approximately the Bear Run horizon were noted in Ripley Township, but no clear sections showing significant details of the member were observed. The member may be present in southeastern Washington Township, but no satisfactory outcrops were observed at its horizon; its horizon may be occupied by the Massillon sandstone.

Carbonaceous shale at the Bear Run horizon is present in a part of Knox Township. In a road ditch 2½ miles south of Nashville and one-fourth mile east of fractional Sec. 13, the Bear Run member is represented by 7 inches of coal blossom underlain by 3 feet 6 inches of light, plastic clay. The coal is 52 feet 8 inches below the Lower Mercer limestone (31-319, Appendix). In the western part of the township, 1 foot 3 inches of carbonaceous shale, lying 50 feet below the Lower Mercer limestone, cropping out along a road 200 yards north of partial Sec. 15, probably represents the Bear Run member (28-332).

Carbonaceous strata at the Bear Run horizon are not conspicuous in Monroe Township, in part because of lack of exposures (in the northern part of the township), in part because of replacement by sandstones, and in part because of lack of deposition. Along an abandoned road, 1 mile north-northeast of Welcome, 4 inches of shaly coal blossom, lying 67 feet below the Lower Mercer limestone, represents the Bear Run member (39-248). An unusual thickness of 7 feet 6 inches of light, plastic, siliceous clay lies below the coal. In a ravine 1 mile east of the Knox Township line and 1⅝ miles north of the Richland Township line, the Bear Run member consists of 7 inches of coal, with no clay beneath, lying 8 feet above the Quakertown coal, which has been mined nearby (36-313, Appendix). Three-fourths mile to the north-northwest, the horizon of the Bear Run member is taken by sandstone (35-358A).

No carbonaceous strata that could be referred to the Bear Run horizon were observed in Hardy Township. Outcrops at this stratigraphic position are poor, but indications are that sandstone is present at most exposures.

In Berlin Township the Bear Run member is due only in the valley of Sand Run in the southwestern corner and in the valley of Doughty Creek near the south boundary. Massillon sandstone occupies the horizon at these two localities.

The horizon of the Bear Run coal is occupied throughout much of Mechanic Township by Massillon sandstone. Where this sandstone is not present the Bear Run member was not positively identified, although at a few places thin, carbonaceous shale underlain by impure clay crops out at the approximate horizon.

The Bear Run member was not identified in Killbuck or Richland townships. Throughout most of these townships it is replaced by the Massillon sandstone.

VANDUSEN COAL

The Vandusen coal is a thin and economically unimportant coal horizon which extends across Ohio with many wants and discontinuities. Its position is about midway between the Bear Run and Lower Mercer coal horizons. In Holmes County the Vandusen coal is discontinuous and thin, consisting of a few inches of coal or carbonaceous shale lying on the average 46 feet above the Harrison ore and 11 feet below the Lower Mercer coal. Its place is in many places taken by the massive Massillon sandstone, but in a part of Killbuck Township it lies within the sandstone or, rather, between the "lower" (true?) Massillon and the "upper" Massillon sandstone. The clay under the Vandusen coal is generally thin and siliceous, having little value, except in one locality in Knox Township.

The horizon of the Vandusen coal is either below drainage or apparently absent from the section in Salt Creek Township.

Prairie Township.—The Vandusen member is not a conspicuous member in Prairie Township. In a ravine in SW¼NE¼ Sec. 1, a 6-inch layer of cannel coal and its associated clay, lying 64 feet below the Bedford coal, is probably the Vandusen member (18-71, Appendix).

Along a road in W Sec. 13, black, carbonaceous shale, exposed along a road at an elevation of approximately 1,050 feet, represents the Vandusen member. Its position is 32 feet 6 inches below the Lower Mercer limestone and 51 feet below the Bedford coal, which is poorly exposed to the north in SW¼ Sec. 12 (21-48, Appendix).

Ripley and Washington Townships.—No data were secured on the Vandusen horizon in Ripley Township. The member may be present, but if so is concealed by glacial drift. In Washington Township the member may be present in the high land in the southeastern part of the township, but no outcrops were seen; its horizon may be occupied by sandstone.

Knox Township.—The Vandusen member appears to be very poorly developed in Knox Township, its horizon being generally occupied by sandstone. However, it was identified, together with 7 feet of underlying clay, in an outcrop along the road 2½ miles south of Nashville and one-fourth mile east of partial Sec. 13 (31-319, Appendix).

Monroe Township.—A few inches of carbonaceous shale or shaly coal, accompanied by approximately 2 feet of sandy clay, crop out at several localities in Monroe Township at the Vandusen horizon. No significant or important characteristics are worthy of note.

Hardy Township.—Carbonaceous material at the Vandusen horizon is not abundant in Hardy Township. A thin coal, lying above the Massillon sandstone in an exposure in a ravine three-fourths mile due west of the northwest corner of Millersburg corporation, is tentatively correlated as Vandusen (49-239B, Appendix).

Berlin Township.—The Vandusen member was not observed in Berlin Township. It is below drainage in Walnut Creek Township.

Clark Township.—The horizon of the Vandusen member is due above drainage in the southwestern corner of Clark Township, near the level of Mill Creek in W½ Sec. 25, but its place is occupied by massive sandstone. In the northwestern corner of the township it is due in NW¼ Sec. 5, but here also the coal is replaced by sandstone.

Mechanic Township.—The Vandusen member is not well developed in Mechanic Township. In the northeastern corner of the township, in NE¼ Sec. 1, a few ½-inch coaly streaks in a clay shale, lying 39 feet below the Lower Mercer limestone and 14 feet below the Lower Mercer coal, at an altitude of approximately 1,010 feet, may represent the Vandusen (122-78, Appendix).

South of Military Run, in N Sec. 13, 2 inches of Vandusen coal overlies 3 feet 1 inch of plastic clay. The coal has an elevation of 1,015 feet, lies 34 feet below the Lower Mercer limestone, and 11 feet 5 inches below the Lower Mercer coal. Over the coal is 11 inches of calcareous ore, the Poverty Run member (138-259).

Killbuck Township.—Sandstone occupies the rock column from the Quakertown coal horizon to just below the Lower Mercer limestone in much of Killbuck Township, and at such places the Vandusen coal horizon is absent. However, the sandstone is at some exposures separated into two divisions by a shale "break," and in this occurrence thin layers of carbonaceous material are commonly associated with the shale. These relations are best shown at an outcrop near the road in SW¼SE¼ Sec. 8, in the northeastern part of the township, where 1 foot 6 inches of shale, the lower one-third of which is carbonaceous, lying 40 feet below the Lower Mercer limestone, is identified as Vandusen. The shale is underlain by 54 feet 8 inches of massive Massillon sandstone and is overlain by 16 feet 6 inches of coarse sandstone (148-31, Appendix).

Richland Township.—No exposures of the Vandusen member were observed in Richland Township.

POVERTY RUN MEMBER

Overlying the Vandusen coal in Muskingum County is a member composed of limestone and iron ore, named the Poverty Run from outcrops on a stream of that name.[1] At a few places in Holmes County a few

[1] Stout, W., Geology of Muskingum County: Geol. Survey Ohio Bull. 21, p. 65, 1918.

inches of iron ore or ferruginous shale overlies the Vandusen coal. No limestone at this horizon was observed in the county. The ore is thin and discontinuous and has no economic value.

The member was seen at only one place in Knox Township, where, in a road ditch 2½ miles south of Nashville and one-fourth mile east of partial Sec. 13, the Poverty Run member is represented by 1 inch of nodular ore and 3 inches of ferruginous shale overlying the Vandusen coal horizon (31-319, Appendix).

In several ravines in central western Monroe Township an ore having a maximum thickness of 10 inches crops out above a thin coal which is correlated as Vandusen.

In Mechanic Township the Poverty Run member is exposed along a road south of Military Run, in N Sec. 13. At this locality 11 inches of nodular ore overlies thin Vandusen coal (138-259, Appendix).

LOWER MERCER COAL AND CLAY

STRATIGRAPHY AND EXTENT

In Holmes County in the interval, averaging just less than 25 feet in thickness, below the Lower Mercer limestone are three persistent, thin coal beds and their associated clays. The lowest of the three coals is called the Lower Mercer coal. Following Stout's usage,[1] the coal lying about in the middle of the interval, at some localities closer to the bottom and at others closer to the top, is called the Flint Ridge coal. The topmost of the three coals, lying directly under the Lower Mercer limestone, is the Middle Mercer coal. The Lower Mercer coal has been mined at three places in Holmes County; in eastern Ripley Township, in northwest central Monroe Township, and in the southeastern part of Mechanic Township.

The Lower Mercer coal, which is generally a carbonaceous shale in place of a true coal, is usually less than 1 foot in thickness at most outcrops, and appears not to be more than 2 feet 2 inches in thickness at any place. The underlying Lower Mercer clay is thin, at few places exceeding 2 feet in thickness. The average interval from the base of the Lower Mercer limestone to the base of the Lower Mercer coal is 23 feet 6½ inches. On the average, the Lower Mercer coal lies 11 feet and 1 inch above the Vandusen coal, which is only locally present in Holmes County.

The Lower Mercer coal is impure and shaly and in many places passes into a carbonaceous shale. Where the Lower Mercer coal expands in thickness, it seems to become more shaly so that attempts at mining are bound to be disappointing. The Lower Mercer coal and clay are of little stratigraphic importance, because for positive identification they must be referred to the overlying Lower Mercer limestone.

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[1] *Ibid.*, pp. 65-66.

The clay underlying the Lower Mercer coal is commonly thin and siliceous. However, at a few places, the Flint Ridge clay, which is ordinarily found a few feet above the Lower Mercer coal, lies directly upon the Lower Mercer coal and the two clays combined in one bed may approach a thickness which gives the beds some importance. However, these places are not common and the clay of both beds is of a much poorer quality than the much more extensive Brookville or Lower Kittanning clays which are so widely distributed throughout Holmes County.

Overlying the Lower Mercer coal at a few localities is a few inches of an iron ore which is referred to as the Boggs member. This ore is so discontinuous and wanting in so many places that it is not of much aid as a stratigraphic marker nor as a means of identifying the Lower Mercer coal.

The Lower Mercer coal and clay are above drainage in every township in the county. However, in Paint, Walnut Creek, and Clark townships, the horizon crops out along the main stream in only one or two localities in each township.

Paint Township.—In the few sections at hand of the rocks at this horizon from the southern part of Paint Township, it appears that the Lower Mercer coal and clay are absent, their places being taken by sandy shale.

Salt Creek Township.—Because the valleys of Salt Creek Township are choked with glacial drift, outcrops of the strata at the horizon of the Lower Mercer coal are scarce. Evidence available indicates that the Lower Mercer coal and clay are discontinuous and thin or wanting in most places where due in Salt Creek Township.

Prairie Township.—In Prairie Township the Lower Mercer coal is thin but fairly steady. At no place observed does it reach as much as a foot in thickness. The underlying clay is thin or absent. In the southeastern part of Prairie Township, in SW¼SW¼ Sec. 12, one-half mile east of Hammond School, the Lower Mercer coal is 10 inches thick and shaly in character. No clay lies beneath the coal. The coal is 22 feet 4 inches below the base of the Lower Mercer limestone (21-48, Appendix). In the southwestern part of Prairie Township where the strata crop out in a road ditch in NE¼SW¼ Sec. 7, the character and thickness of the coal and clay under discussion are recorded as follows:

	Ft.	In.
Shale, sandy, ferruginous, *Boggs* horizon	3	0
Coal, shaly, *Lower Mercer*	0	9
Clay, light, plastic	2	6
Shale, siliceous	3	0

Ripley Township.—Because of the thick covering of glacial drift over most of Ripley Township, exposures of the bedrock are, in general, few and unsatisfactory. However, in central eastern Ripley Township, the Lower Mercer coal is much thicker than average. In SE¼SW¼

Sec. 1, a small amount of the coal has been mined from an opening just north of the south boundary of the section. The coal is too thin for large-scale mining and is somewhat bony, burning with a high ash content. It will never have more than a restricted local use. Where measured along the road one-eighth mile east of the mine, the interval from the base of the Lower Mercer coal to the Lower Mercer limestone is 28 feet 8 inches (20A-353, Appendix). The following section measured at the mouth of the mine is illustrative of the character and thickness of the Lower Mercer coal at this locality:

		Ft.	In.
Shale, sandy; with 1- to 2-inch white sandstone layers		12	0
Sandstone, white, hard; with plant fossils.		0	3
Shale, soft, gray; in very thin layers		3	10
Coal, fair	*Lower Mercer* altitude 1,120 feet	1	4
Shale, hard, black, bone		0	3½
Clay, light gray, hard, siliceous		1	2

It is not believed that the Lower Mercer coal increases in thickness nor improves in quality in any direction from this small mine. To the east, in Prairie Township, the coal is more shaly and thinner than it is in Sec. 1, Ripley Township, and less than a mile to the west the Lower Mercer is made up of 2 feet 6 inches of carbonaceous shale (23-245, Appendix).

Washington Township.—The horizon of the Lower Mercer coal and clay is found on the hilltops in the central southern and the southeastern portions of Washington Township. The Lower Mercer limestone is almost indispensable as a guide horizon for the thin coal beds below it and the limestone is absent or concealed where it is due in the central southern and southeastern parts of the township. However, a thin coal bed tentatively identified as the Lower Mercer crops out along the bank of the state road just below the cemetery at the northwest corner of Nashville at an elevation of approximately 1,220 feet. One mile to the northwest along the same road, in central E Sec. 14, a thin coal bed, probably the Lower Mercer, is present at an altitude of about 1,200 feet.

Knox Township.—In Knox Township the Lower Mercer coal is thin and unsteady. At most places the underlying clay is also thin and impure. In the eastern part of the township in a ravine 1 mile south-southeast of Stone School and five-eighths mile west of the Knox-Monroe township line, the Lower Mercer coal horizon is represented by 2 feet 3 inches of carbonaceous shale at an elevation of 1,200 feet, lying 17 feet below the Lower Mercer limestone (26-324, Appendix).

In the central part of the township, a little more than a mile north of Cross School and one-fourth mile east of partial Sec. 13, a 3-inch seam of Lower Mercer coal crops out along a road and is underlain by 1 foot 7 inches of light gray siliceous clay. Here the Lower Mercer coal lies 30 feet below the Lower Mercer limestone (31-319, Appendix). In the western part of the township along Kaylor Ridge, the Lower Mercer coal is reduced to a smut streak or is totally absent. The Lower Mercer clay is 5 feet 6 inches thick, however, at an outcrop along the Greer-Nashville road in NW¼NE¼ Sec. 16 (29-333).

Monroe Township.—In Monroe Township the Lower Mercer coal is thicker than the average throughout the county. Its character is known mainly from the central portion of the township. One mile north-northeast of the hamlet of Welcome the Lower Mercer coal consists of a 1-foot blossom (39-248, Appendix).

In the western central part of Monroe Township the Lower Mercer coal has been mined just west of the road 1 mile north of Birds School and 2 miles northwest of Welcome, in the headwaters of Shrimplin Creek, on the farm of Edward Bart. The mine has long since fallen in, but Mr. W. B. Remington, who formerly mined coal from this bank, reported that the coal has a maximum thickness of 3 feet at places in the mine but thins rapidly in all directions from the maximum. The roof is reported to be "soap stone" and to be poor toward the edges of the basin where the coal is thin. The coal is said to burn well, leaving a white ash. Beneath the mined coal is about 5 inches of "dirt and coal" into which the coal was cut. About 3 inches of bone coal overlies the minable bed. The discontinuousness of the coal is shown by the fact that a well drilled on the farm of Neil Powers one-half mile northeast found no coal at this horizon. As noted above, this old mine has fallen in so that no measurements of the coal are now possible, but the following data taken along the road just east of the old mine show the relationship of the Lower Mercer coal horizon to the Harrison ore—the basal member of the Pottsville:

	Ft.	In.
Pennsylvanian System		
Pottsville formation		
Sandstone, shaly to thin-bedded	14	0
Shale, siliceous to sandy	20	0
Covered	56	6
Sandstone, light, clay-bonded	8	0
Coal, old mine, *Lower Mercer,* altitude 1,120 feet	3	0
Shale, sandy; sandstone; and covered	39	10
Shale, sandy	6	0
Shale, clay-like	4	0
Sandstone, coarse, massive, impure	1	2
Ore, sandy, irregular, somewhat nodular; weathered, *Harrison*	0	8
Mississippian System		
Logan formation		
Sandstone, thin-bedded, *Vinton*	10	0

The Lower Mercer carbonaceous member, underlain by thin, impure clay, crops out in a ravine one-half mile east of the Knox Township line and 2¼ miles north of the Richland Township line. The interval from the coal to the overlying Lower Mercer limestone is 19 feet 3 inches (35-358A, Appendix). The member is composed of 2 feet 3 inches of carbonaceous shale, in part sandy and ferruginous. It is interesting to note that the strata here are much disturbed by faulting, the total throw of which is 3 feet.

Hardy Township.—Where seen in Hardy Township, the Lower Mercer coal horizon is occupied by carbonaceous shale and the underlying Lower Mercer clay is either absent or very thin and sandy. The carbonaceous shale representing the Lower Mercer coal in Hardy Township seems to be the thickest in the northwestern part. Along the road one-fourth mile northwest of the Oak Ridge School, 1 mile northwest of Millersburg, the Lower Mercer horizon is made up of 2 feet of carbonaceous shale (48-237).

In a ravine 1 mile west of Killbuck Creek and five-eighths mile north of Sapps Run, the Lower Mercer coal is represented by 1 foot of hard, carbonaceous shale. No clay is present beneath the coal (49-239B, Appendix).

Berlin Township.—Outcrops of the Lower Mercer coal in Berlin Township are confined to the southern portion, where the coal is thin and shaly. The Lower Mercer clay is either very siliceous or its place is taken by a shale.

Two miles south of Berlin and half a mile northeast of Wise School, along the road just east of Doughty Creek, 7 inches of shaly Lower Mercer coal is overlain by nodular Boggs ore (72-46). In the bed of a small tributary to Doughty Creek, just south of the road forks three-fourths mile south of Wise School, the Lower Mercer coal is 1 foot 3 inches thick and has an elevation of 1,000 feet. It is overlain by 2 inches of grayish-brown, dense, impure ore, the Boggs, with the intervention of 1 foot of dark gray shale between the ore and the coal. Underneath the coal is 2 feet of dark gray shale which contains many plant fossils.

In the southwestern portion of the township the Lower Mercer coal is of very little importance and the Lower Mercer clay is absent. In NE¼ partial Sec. 23 the Lower Mercer coal is represented by 1 foot 8 inches of hard, black, bone shale lying 18 feet 8 inches below the Lower Mercer limestone. No clay occurs underneath the Lower Mercer coal at this place (68-60, Appendix). One mile northeast of Saltillo in the banks of a small stream just north of the road, the Lower Mercer coal is 5 inches thick (69-22, Appendix).

Walnut Creek Township.—The Lower Mercer coal and clay are below drainage in all of Walnut Creek Township except possibly along Walnut Creek in the northeastern part, where only poor exposures are visible at this horizon.

Clark Township.—The Lower Mercer coal is the lowest coal horizon cropping out in Clark Township. It is exposed only in the extreme northwestern and extreme southwestern portions. In the southwestern part it is due in the headwaters of Mill Creek, but its place is taken by sandstone. In the northwestern part it is present in central Sec. 5, northwest of Charm, just above the level of a tributary of Doughty Creek. The coal, which is shaly and ranges from 8 to 18 inches in thickness, crops out along the road at an elevation of 1,030 feet (102-62, Appendix).

Mechanic Township.—The horizon of the Lower Mercer coal is widely distributed over Mechanic Township. This member is present, however, only in the eastern and central parts of the township; elsewhere its place is taken by shale or sandstone. In the northeastern corner of Mechanic Township, in a ravine south of the road in NE¼NE¼ Sec. 1, 3 feet 6 inches of carbonaceous shale represents the Lower Mercer (122-78).

In NE¼NE¼ Sec. 10, in a road ditch just north of Troyers Mill, the Lower Mercer coal is 1 inch thick, but 5 feet 7 inches of grayish to black carbonaceous shale overlying it doubtless represents the same horizon (123-82, Appendix). To the southwest the coal remains thin and the carbonaceous shale disappears. Along the road just south of Military Run in N½ Sec. 13, the Lower Mercer coal is 4 inches thick and extremely shaly (138-259).

In the southeastern corner of Mechanic Township lies the thickest deposit of Lower Mercer coal observed anywhere in Holmes County. A small amount of the coal has been mined from N central Sec. 21 on the farm of Henry Brenly. The coal is of very poor quality and burns with a high ash content. The coal is exposed along the road in SE¼NW¼ Sec. 21 just south of the abandoned mine, and the following measurements were secured:

		Ft.	In.
Shale, sandy, micaceous; with plant fossils		40	0
Covered		5	0
Sandstone, shaly		2	0
Shale, black, carbonaceous, slaty,	*Lower Mercer* altitude 970 feet	5	10
Coal, bony and shaly, poor		2	2
Clay shale		1	0
Covered		18	0

The relationship of the Lower Mercer coal to the overlying Lower Mercer limestone is shown one-quarter mile to the southeast, along the road. It will be noted that the Lower Mercer coal is reduced rapidly in thickness, which is characteristic of this member wherever observed in Holmes County. The fact is noteworthy that this member is entirely absent from the section one-half mile farther east in the southwestern part of Clark Township. The data secured in NE¼SE¼ Sec. 21 follow:

		Ft.	In.
Road fork, altitude 1,020 feet.			
Shale, ferruginous		3	0
Limestone, loose blocks, *Lower Mercer*		2	0
Clay and covered		8	0
Shale and covered		6	0
Shale, sandy		8	0
Shale and covered		18	7
Shale, hard, dark, carbonaceous	*Lower Mercer*	1	0
Shale, dark gray	*Lower Mercer*	0	3
Coal, poor	*Lower Mercer*	0	2

A thin coal stratum, which is thought to be the Lower Mercer, crops out in the central southern part of Mechanic Township. The thickness and character of the coal and of the thin underlying clay along the north-south road one-half mile north of Doughty Creek and 1 mile northeast of the village of Clark are as follows:

	Ft.	In.
Sandstone	45	0
Coal, shaly, *Lower Mercer,* altitude, 1,015 feet	0	7
Clay and covered	2	0
Sandstone	10	6
Ore, sandy, *Poverty Run?*	0	6
Sandstone, massive to medium-bedded, *Massillon*	28	4

Killbuck Township.—In Killbuck Township the Lower Mercer coal horizon was at no place observed to be more than a few inches of carbonaceous shale (146-346, Appendix). The clay below, where present, is about 1 foot in thickness and extremely sandy and impure. The member is commonly replaced by sandstone.

Richland Township.—The Lower Mercer coal is wanting where the strata at this horizon were seen in Richland Township. In the central part of the township on French Ridge the Lower Mercer coal and clay have been replaced by sandstone. In the northwestern part shale occupies the position of the member.

ECONOMIC VALUE

Throughout most of Holmes County the Lower Mercer coal has no economic value. As mentioned in the areal description, it has been mined from three localities in Holmes County—in Ripley, Monroe, and Mechanic townships—where one opening in each locality has been driven. From each of the three small mines only a little fuel for local use was mined and the mines are now abandoned. Where the coal reaches its maximum thickness in these three localities, it is thin and shaly and the writer saw no Lower Mercer coal that was thicker than 2 feet 2 inches. The coal is extremely shaly and bony and burns with a high ash content. It is possible that in the future an occasional opening for fuel for nearby household use may be driven, but only where ease of extraction and difficulty of securing better fuel supplies make it necessary.

The Lower Mercer clay is generally thin and very siliceous or impure, and, except at one or two localities where it is so close to the overlying Flint Ridge clay that both clays could be mined at the same time, it will probably never be of use for ceramic purposes.

BOGGS ORE

The Boggs member, which is marked by ore deposits in southern Ohio[1] and by ore, limestone, and flint in central Ohio, especially in Muskingum County,[2] is in Holmes County very unsteady and is absent from the stratigraphic column at most places. Where it does occur, it forms a very thin bed of iron ore immediately overlying the Lower Mercer coal. No limestone or flint was observed at this horizon in Holmes County. The deposits were evidently laid down in a very discontinuous lagoon in which much clastic material was being deposited, so that the ferruginous material which was concentrated as an ore in some parts of Ohio was scattered through sandstone and shale, making a ferruginous shale in Holmes County. Marine fossils are found in some localities at this horizon so that the member is known to be of marine origin.

The bed is so unsteady that few measurements of a true ore could be secured, thus no average thickness can be calculated. The thickest outcrop of the ore is 10 inches. The Boggs lies at most places on top of the Lower Mercer coal. The Lower Mercer coal is on the average 23 feet 6½ inches below the base of the Lower Mercer limestone. The interval between the Boggs ore and the Middle Mercer clay is generally occupied by shale, except where the very thin Flint Ridge coal and its underlying clay are present. The Lower Mercer coal, which underlies the Boggs ore, is much more persistent than the ore. In some places strata which once occupied the horizon have been replaced by sandstone.

The Boggs ore is of no economic importance and of very little stratigraphic importance. It is found at so few places and is so thin that it is of no help in identifying other beds. The Boggs, itself, can only be identified by referring it to the overlying Lower Mercer limestone.

In Paint Township and in Salt Creek Township the horizon of the Lower Mercer coal and of the Boggs ore is occupied, locally, by sandstone or by sandy shale. In Prairie Township the Lower Mercer coal crops out at a few places but no marine stratum overlies it.

Ripley Township.—In central eastern Ripley Township, where the Lower Mercer coal is exposed, the overlying material is sandy shale and is neither calcareous nor ferruginous. However, in the northeastern corner of the township some ore layers, tentatively identified as Boggs, are present without indication of any Lower Mercer coal. The following record

[1] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 104, 1927.
[2] Stout, W., Geology of Muskingum County: Geol. Survey Ohio Bull. 21, p. 70, 1918.

was secured along the boundary line between Wayne and Holmes counties in NE¼NW¼ Sec. 25:

		Ft.	In.
Sandstone, medium-grained, buff to yellow		6	0
Sandstone, white, clay-bonded		3	6
Clay, light, plastic	*Flint Ridge?*	3	0
Clay, gray, somewhat carbonaceous	*Flint Ridge?*	0	6
Clay, light, plastic, siliceous	*Flint Ridge?*	4	0
Covered		7	9
Sandstone, shaly		3	0
Ore, blue gray, sandy, massive; weathers into blocks like bricks	*Boggs?* altitude 1,110 feet	0	4
Ore, shaly	*Boggs?* altitude 1,110 feet	0	1½
Ore, massive, sandy	*Boggs?* altitude 1,110 feet	0	2
Ore, shaly	*Boggs?* altitude 1,110 feet	0	2
Shale, sandy		1	4

In Washington, Knox, Monroe, and Hardy townships the Boggs ore at most places is absent because of lack of deposition. At some exposures, however, the Boggs and associated strata have been replaced by sandstone.

Berlin Township.—At most places in Berlin Township the condition succeeding the deposition of the Lower Mercer coal was favorable for the deposition of shale but not for the deposition of iron ore or calcareous material. However, in the south central part and in the southeastern part some slight amount of ferruginous material was laid down immediately over the Lower Mercer coal (72-46, Appendix.)

In the central southern part of Berlin Township the Boggs member is exposed in the bed of a small stream tributary to Doughty Creek, just south of the road forks three-fourths mile south of Wise School, where the following section was measured:

	Ft.	In.
Sandstone, irregular, massive	25	0
Shale, gray	6	0
Ore, gray brown, dense, impure, *Boggs,* altitude 1,000 feet	0	2
Shale, dark gray	1	0
Coal, bony, *Lower Mercer*	1	3
Shale, dark gray; many plant fossils	2	0
Shale, sandy	2	0
Sandstone, thin-bedded to massive, *Massillon*	10	0

Walnut Creek Township.—The strata at this horizon are under cover in Walnut Creek Township.

Clark Township.—The Lower Mercer coal and associated strata are under cover in all of Clark Township except in the extreme northwestern and the extreme southwestern portions. Here, although the Lower Mercer coal lies near the bottom of the valleys, no ore or calcareous material overlying the Lower Mercer coal was seen.

Mechanic Township.—Although the horizon of the Boggs is due from place to place in Mechanic, Killbuck, and Richland townships, there are no indications of iron ore or of calcareous material overlying the Lower Mercer coal at the outcrops studied. At many places the Lower Mercer coal also is absent, the place of the Lower Mercer coal and the Boggs being taken by sandstone or by shale.

FLINT RIDGE COAL AND CLAY

STRATIGRAPHY AND EXTENT

The Flint Ridge coal lies about midway in the interval between the Lower Mercer coal and the Middle Mercer coal: the Middle Mercer coal lies directly beneath the Lower Mercer limestone. The Flint Ridge member is named from its development as a cannel coal of excellent thickness on Flint Ridge, Hopewell Township, Licking County.[1] Elsewhere in Ohio, it has no economic importance. In Holmes County the Flint Ridge coal has an average thickness of 7 inches. Its average distance below the Lower Mercer limestone is 8 feet 8 inches. It is not everywhere present in the section, its horizon at many places being occupied by shale. The clay underlying the coal is almost everywhere thin and impure.

Paint Township.—Throughout most of Paint Township, the strata at the Flint Ridge horizon are under cover. In the valley of Indian Trail Creek in the southeastern corner of the township the strata at this horizon, consisting mainly of sandy shale, crop out at a few localities, indicating that the Flint Ridge coal and clay are absent through lack of deposition. In the northern part of the township, the Flint Ridge coal and clay should be above drainage in the valley of the Middle Fork of Sugar Creek and its tributaries but outcrops are concealed by the thick deposits of glacial drift in the valleys.

Salt Creek Township.—The horizon of the Flint Ridge coal is due in Salt Creek Township along most of the valleys but because they are choked with glacial drift there are few exposures of the rocks at this horizon. A thin, shaly coal observed along a road five-eighths mile east of Fryburg in the central southern portion of the township, is hesitatingly identified as Flint Ridge. Because the Lower Mercer limestone, which should lie a few feet above the Flint Ridge coal, was not found, the identification cannot be positive. The layers measured are as follows:

		Ft.	In.
Clay, sandy, and sandstone, white, clay-bonded		8	0
Coal, weathered, *Middle Mercer?*		0	3
Clay, gray, sandy		3	0
Shale, siliceous to clayey, with ore balls		4	1
Clay shale, gray		1	0
Coal, shaly	*Flint Ridge?* altitude 1,090 feet	0	4
Clay shale, gray		0	2
Coal, shaly		0	2
Clay, impure		1	6
Shale, ferruginous		4	6
Sandstone, thin-bedded, white		2	0

[1] *Ibid.*, p. 75.

In the southwestern part of Salt Creek Township, 8 inches of Flint Ridge coal crops out 6 feet 3 inches below the Lower Mercer limestone along the road 1 mile south of Martinsville (14-13, Appendix).

Prairie Township.—The Flint Ridge coal and clay in Prairie Township are discontinuous, thin, and unimportant. In the northeastern part of Prairie Township the coal is exposed in a ravine in NE¼SW¼ Sec. 25 at an altitude of approximately 1,085 feet. The coal is 6 inches in thickness, of a shaly character, and is underlain by 3 feet of dark, micaceous, very impure clay containing plant fossils (16-54). In the southeastern part of the township, in E½ Sec. 14, the Flint Ridge coal and clay are present but are poorly exposed (20-47).

Ripley Township.—In Ripley Township the Flint Ridge coal and clay are very discontinuous, thin, and impure.

Knox Township.—In Knox Township both the Flint Ridge coal and clay are thin and erratic. The coal is at no place more than a few inches in thickness and is of poor quality, whereas the clay, which locally reaches several feet in thickness, does not hold this thickness for any distance. In central Knox Township, along a road 1¼ miles north of Cross School and one-fourth mile east of partial Sec. 13, at an altitude of 1,250 feet, the Flint Ridge coal is represented by 10 inches of carbonaceous shale and is underlain by 2 feet 6 inches of sandy, somewhat micaceous clay. The base of the coal is 13 feet 2 inches below the Lower Mercer limestone (30-320, Appendix). In the western part of the township, the Flint Ridge coal and clay are exposed at several places near the top of the Kaylor Ridge. In the northern part of partial Sec. 15, the coal is very thin but the clay below is 6 feet 4 inches thick, plastic in character, and somewhat siliceous and grayish yellow in color (28-332). One-half mile south the clay is of a much poorer quality and is thinner (29-333).

Monroe Township.—In Monroe Township the Flint Ridge coal is as thin and as erratic as elsewhere in the county. The underlying clay seems to be somewhat more steady but is unimportant. One mile north of Welcome, in the central eastern part of the township, along an abandoned road, the Flint Ridge coal is represented by 1 foot of carbonaceous shale underlain by 4 feet 8 inches of clay of poor quality (39-248, Appendix), cropping out 8 feet 10 inches below the Lower Mercer limestone at an altitude of 1,075 feet. Underneath the clay lies 1 foot of weathered coal with several feet of poorly exposed clay below the coal, showing the tendency here, as at some other places, for the Flint Ridge clay and the Lower Mercer clay to coalesce with the intervention of only a thin layer of Lower Mercer coal. At some places where the Flint Ridge clay and the Lower Mercer clay come so close together, they may in the future be exploited for ceramic purposes.

In a ravine one-half mile east of Knox Township and 2⅛ miles north of Richland Township, an unusual thickness of carbonaceous material at the Flint Ridge horizon is present. The beds have been considerably disturbed by slipping along joints, displacements of as much as 3 feet being evident. Data on thickness and stratigraphic position, which are a part of 35-358A, Appendix, are as follows:

		Ft.	In.
Limestone, gray blue, *Lower Mercer*		4	1
Shale, black, carbonaceous, sandy, *Middle Mercer*		0	6
Clay, impure		1	0
Shale, gray blue, fine-grained		1	11
Shale, black, carbonaceous, hard	*Flint Ridge*	1	6
Coal, bright, blocky, good	*Flint Ridge*	1	2
Clay shale, gray	*Flint Ridge*	0	6
Shale, black, with coaly streaks	*Flint Ridge*	1	0
Coal, cannel	*Flint Ridge*	0	8
Clay shale, gray	*Flint Ridge*	0	11
Coal, shaly, cannel	*Flint Ridge*	0	2
Coal, bright, blocky	*Flint Ridge*	0	6
Shale, black, bony, canneloid	*Flint Ridge*	0	5
Clay, very impure		1	6

Hardy Township.—In Hardy Township no exposures of coal and clay which could be definitely identified as Flint Ridge were noted. Strata at this horizon are widely distributed over Hardy Township, but in many places are poorly exposed and in others the horizon, where the Flint Ridge coal and clay should appear, is occupied by shale or by sandstone.

Berlin Township.—In Berlin Township strata at this horizon crop out only in the southwestern corner and in the central southern part of the township. Glacial drift conceals any possible outcrop in the central and central northern part of the township. In the southwestern part of Berlin Township the Flint Ridge coal and clay seem to be absent due to lack of deposition, their place being taken by sandy shales. In the central southern portion of the township, 2 feet of white, clay-bonded, ganister-like sandstone, exposed along a road 1 mile south of Berlin, may represent the horizon of the Flint Ridge clay (72-46, Appendix).

Walnut Creek Township.—In Walnut Creek Township strata below the Lower Mercer limestone are obscured by silt filling in the deeper valleys. In the other parts of the township these strata are under cover. At an outcrop along the state road, one-half mile north of the village of Walnut Creek, the Flint Ridge coal is 1 foot 7 inches in thickness and is very impure (87-107, Appendix).

Clark Township.—The horizon of the Flint Ridge members is above drainage only in the northwestern corner of Clark Township in Sec. 5 and in the southwestern corner in secs. 16 and 25. In the northwestern corner, northwest of Charm, sandy shales and shaly sandstones occupy the interval between the Middle Mercer coal and the Lower Mercer coal. The Flint Ridge is therefore absent due to lack of deposition. In the southwestern corner of the township in the valley of Mill Creek, no coal or clay was seen at the horizon of the Flint Ridge. Along the central western border of the township, 4 inches of Flint Ridge coal and 1 foot of clay crops out at the Mechanic Township line in SW¼ SW¼ Sec. 15, lying 7 feet below the base of the Lower Mercer limestone (106-262, Appendix).

Mechanic Township.—Over a large part of Mechanic Township, the horizon of the Flint Ridge coal and clay is occupied by shale and sandstone. Where the Flint Ridge members are present they are commonly thin and impure. At no place are they important stratigraphically or economically. In the northeastern corner of Mechanic Township, the Flint Ridge coal horizon is represented by carbonaceous shale. The underlying clay is thin and very impure and lies directly upon the Lower Mercer coal (123-82).

In the central part of Mechanic Township the Flint Ridge members appear a few feet underneath the Lower Mercer limestone. One-quarter mile south of Webster Hall School, 8 inches of very shaly Flint Ridge coal crops out along a road at an altitude of 1,005 feet. It is underlain by 1 foot of gray, carbonaceous clay. One-half mile east of SE¼SE¼ Sec. 10 and one-eighth mile east of Bucks Run, the following section is exposed along the gravel road:

		Ft.	In.
Shale, sandy		10	0
Limestone, hard, dark blue, fossiliferous, dense to granular, *Lower Mercer*, altitude 1,000 feet		1	0
Clay shale, carbonaceous, *Middle Mercer*		0	2
Clay, light, plastic		0	10
Shale, sandy		1	8
Shale, siliceous		4	0
Coal, shaly	*Flint Ridge*	0	2
Clay	*Flint Ridge*	0	2
Shale, grayish yellow	*Flint Ridge*	0	7
Coal, shaly	*Flint Ridge*	0	4
Clay		1	3

In the western part of Mechanic Township, in SW¼SE¼ Sec. 12, the Flint Ridge coal is represented by 1 inch of coaly shale lying 12 feet 5 inches below the Lower Mercer limestone (136-5, Appendix). The Flint Ridge clay is poorly exposed, but seems to be at least 3 feet in thickness, and to lie directly upon the massive Massillon sandstone.

Killbuck Township.—The place of the Flint Ridge coal in most places in Killbuck Township is taken by shale. The underlying clay is somewhat more steady but still it is erratic, irregular, and thin. One mile southeast of the village of Killbuck, in NE¼ Sec. 15, a few inches of carbonaceous shale, which crops out along the road, is tentatively identified as the Flint Ridge coal horizon. This coaly shale is 5 feet 8 inches below the Middle Mercer coal. The Lower Mercer limestone is absent in this locality (147-273, Appendix).

In the central western part of the township Flint Ridge clay, about 4 feet thick, is poorly exposed along a road in NE¼SW¼ Sec. 8 at an elevation of 1,155 feet, 13 feet below the Lower Mercer limestone (143-299). In the central southern part of the township, the Flint Ridge coal is very thin. The clay, 2 feet thick, lies 11 feet below the Lower Mercer limestone where it outcrops at an altitude of 1,080 feet along the road ditch in SE¼SE¼ Sec. 22 (146-346, Appendix).

Richland Township.—At most places in Richland Township, the Flint Ridge coal and clay are absent where due. At some places shale occupies the horizon and at others sandstone. However, in the northwestern part of Richland Township along Kaylor Ridge, the Flint Ridge coal and clay are very well developed. Along the road in SW¼NW¼ Sec. 4, a 1-foot 3-inch blossom of the coal was measured (162-379).

ECONOMIC VALUE

In Holmes County the Flint Ridge coal is too thin and impure for mining. It will never be of any economic importance.

The Flint Ridge clay is generally thin and impure. At a very few places, however, in Knox and Monroe townships, where it lies close to the overlying Middle Mercer clay or close to the underlying Lower Mercer clay, the combined clays of the two members might, at some future date, assume some importance. However, clays of so much greater extent and of so much higher quality remain unexploited that it will be a long time before the Flint Ridge member is considered for ceramic purposes.

MIDDLE MERCER COAL AND CLAY

STRATIGRAPHY AND EXTENT

The Middle Mercer coal, which lies directly under, or with intervention of 1 or 2 inches of clay shale, the Lower Mercer or "Blue" limestone, is a very persistent bed in Holmes County. The bed extends "with fair continuity from the Ohio-Pennsylvania line in Mahoning County to the Ohio River, in Scioto County. Throughout this field the member expands in few places sufficiently to be mined even in a small way."[1]

In Holmes County the coal is commonly from 2 to 4 inches in thickness but at places may reach a thickness of as much as 1 foot and at two places thicknesses greater than 3 feet were observed. However, where the bed is more than a few inches in thickness, it is composed of carbonaceous shale and hence it is valueless for fuel purposes and mines have never been opened in the bed. Although such openings have been considered, on closer examination of the outcrop, it was seen that the coal is really a shale and not suitable for fuel.

The Middle Mercer coal and clay are coextensive with the overlying Lower Mercer limestone, which is described in detail throughout

[1] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 119, 1927.

the county, and many of the sections illustrative of the Lower Mercer limestone also show the character and thickness of the underlying coal and clay.

The clay which underlies the Middle Mercer coal is generally thin, siliceous, and impure. It is commonly clay shale rather than true clay. At several localities, however, its thickness and quality are somewhat improved, and these are noted.

Paint Township.—The best outcrops are present along the valley of Indian Trail Creek in the southern part of Paint Township. The Middle Mercer coal is about 2 inches in thickness, and the underlying clay is from 2 to 3 feet thick.

Salt Creek Township.—Because of the covering of glacial drift few outcrops of this member are seen in Salt Creek Township. In the southwestern part, the Middle Mercer coal horizon is represented by 8 inches of dark, carbonaceous clay underlying the Lower Mercer limestone along a road 1 mile south of Martinsville and five-eighths mile north of the Hardy Township line, at an altitude of approximately 1,115 feet (14-13, Appendix). The clay underneath the coal is of fair quality and thicker than usual, 4 feet 11 inches.

Prairie Township.—The Middle Mercer coal in Prairie Township consists of a very few inches of carbonaceous shale or very shaly coal. The Middle Mercer clay is thin and of poor quality.

Ripley Township.—Because of the glacial drift in Ripley Township, few bedrock exposures at the horizon of the Lower Mercer limestone and Middle Mercer coal are observed. No unusual character of the Middle Mercer coal and clay was seen except in secs. 1 and 2 in the central eastern part. Here the coal horizon is represented by 6 inches of carbonaceous shale, and the underlying clay is of fair quality and 6 feet in thickness (23-245, Appendix).

Knox Township.—Both the Middle Mercer coal and the Middle Mercer clay are somewhat thicker than the average in Knox Township. In a ravine in central eastern Knox Township, three-eighths mile northwest of Bell Ridge School, 2 feet of hard, carbonaceous shale was deposited during Middle Mercer time. The clay underneath the coal is thin and impure (27-271 Appendix). In the central part of the township, 1¼ miles north of Cross School and one-fourth mile east of partial Sec. 13, at an altitude of 1,240 feet, 1 foot of coaly shale underlies the Lower Mercer limestone which crops out along a road. Here 4 feet 2 inches of light gray, plastic clay directly underlies the coal (31-319). One-quarter mile southwest, 10 feet of siliceous clay is exposed in a road ditch (30-320). In the western part of the township along Kaylor Ridge, the Middle Mercer coal is present under the Lower Mercer limestone in secs. 15 and 16. In the road ditch of the Nashville-Greer road in NW¼NE¼ Sec. 16 at an altitude of 1,300 feet, the Middle Mercer coal, 4 inches thick and of fair quality, is underlain by 3 feet of gray, plastic clay. The coal here is 5 feet 6 inches above the thin Flint Ridge coal (29-333).

Monroe Township.—In Monroe Township the Middle Mercer coal is very thin and shaly and the underlying clay at few places reaches more than 1 foot in thickness.

Hardy Township.—The Middle Mercer coal and clay are very difficult to find in Hardy Township because the overlying Lower Mercer limestone is thin or wanting over large parts of the township. No data are at hand to indicate that the Middle Mercer coal and clay are above the average in thickness and quality in this township.

Berlin Township.—The coal and clay under discussion crop out only in southern Berlin Township. In a ravine three-fourths mile north of Saltillo just north of a road in NE partial Sec. 23, the Middle Mercer coal is 3 inches thick, and is separated from the overlying Lower Mercer limestone by 1 inch of clay shale. The clay underneath the coal is somewhat ferruginous and 4 feet in thickness (68-60, Appendix). South of Berlin and east of Wise School the coal reaches a maximum thickness of 6 inches and the underlying clay a maximum of 2 feet at several outcrops.

Walnut Creek Township.—Where the Middle Mercer coal crops out near the valley bottom in the valleys of Indian Trail Creek and Walnut Creek and its tributaries, it is from 2 to 4 inches in thickness, with about 1 inch of clay shale between the overlying Lower Mercer limestone and the coal. The Middle Mercer clay is 2 to 3 feet in thickness and poor in quality. In the southeastern part of Walnut Creek Township, however, the Middle Mercer coal reaches an unusual thickness. In central Sec. 16, the coal is 11 inches in thickness and the underlying clay 2 feet in thickness. The coal is of very poor quality as is the underlying clay. One mile to the south along a road in NE¼SW¼ Sec. 25, the Middle Mercer coal is 3 feet 1 inch in thickness and is very shaly (93-134, Appendix).

Clark Township.—The Middle Mercer coal in Clark Township is known only from outcrops in the northwestern part in the vicinity of Charm and in the southwestern part from the headwaters of Mill Creek. Elsewhere it is below drainage. At most outcrops the Middle Mercer coal is of poor quality and has a thickness of 2 to 3 inches, whereas the underlying clay is 2 to 3 feet thick and generally impure. At some places, 1 or 2 inches of clay shale intervenes between the Middle Mercer coal and the overlying Lower Mercer limestone.

Mechanic Township.—Wherever in Mechanic Township the Lower Mercer limestone is found the Middle Mercer coal is present immediately below it. The coal is usually of poor quality and at few places more than 2 or 3 inches in thickness. The underlying clay is 1 to 3 feet in thickness and generally impure. However, in the central part of Mechanic Township, the coal increases greatly in thickness, although the quality remains poor. In the central western part of Mechanic Township, in SW¼SE¼ Sec. 12, the Middle Mercer coal is represented by 3 feet 11 inches of dark, carbonaceous shale directly underlying the Lower Mercer limestone (136-5, Appendix).

In the central part of the township, also, the Middle Mercer seems to be much thicker than average. The character of the coal and of the underlying clay and the relationship to the overlying Lower Mercer limestone is as follows in a road ditch just north of the east-west road, one-fourth mile east of Bucks Run and five-eighths mile east of NE¼ Sec. 11:

	Ft.	In.
Shale	2	0
Ore	0	1
Limestone, hard, dark blue, slightly granular, fossiliferous; a very little flint, *Lower Mercer,* altitude 1,020 feet	2	2
Clay shale	0	3
Shale, dark, carbonaceous, almost coal, *Middle Mercer*	1	9
Clay, plastic, gray to yellow	1	3
Clay shale, yellow	2	0

Killbuck Township.—The Middle Mercer coal is found everywhere just beneath the Lower Mercer limestone and with a thickness nowhere of more than 2 to 3 inches, except in the southeastern part of Killbuck Township. In the southeastern part, the Middle Mercer coal horizon is occupied by a carbonaceous shale which may reach a thickness of more than a foot (151-74, Appendix). This is part of an area of rather thick carbonaceous shale described just above in central and central eastern Mechanic Township to the east.

Richland Township.—In Richland Township, the area of the Middle Mercer coal and clay is small, as is that of the overlying Lower Mercer limestone. In the central part of Richland Township, the Lower Mercer limestone and the Middle Mercer coal are replaced by sandstone and shale. Where the Middle Mercer coal crops out in the northeastern corner along Kaylor Ridge, in the northwestern part, and near the Holmes-Coshocton county line at the southeastern corner of Richland Township, it is very thin and shaly, at few places having a thickness of more than 3 or 4 inches. The underlying clay, which locally reaches a thickness of as much as 4 or 5 feet, is impure, especially in the northwestern part of the township where it is very sandy and micaceous. A maximum thickness of 8 feet 4 inches of Middle Mercer clay is exposed in SW¼NE¼ Sec. 4, three-fourths mile northwest of Dino School, where the sandy and micaceous character of the clay is very evident where it crops out along a road (161-380, Appendix).

ECONOMIC VALUE

Although widely distributed in Holmes County, the Middle Mercer coal is of trifling value, except at a very few localities, as the bed is much too thin to mine and at the localities where coal is thick enough for local mining it is of a shaly nature. It is therefore of no value as a source of fuel in the county.

The clay underlying the coal although widely extensive, is likewise generally thin, siliceous, and impure. At a few localities the clay may sometime be of use, although the abundant supplies of better and thicker clays, such as the Brookville and the Lower Kittanning, which lie closer to the railroad, make it likely that the Middle Mercer clay will never be of very great ceramic importance. As already described, localities where the clay may have some future value are: near Martinsville in Salt Creek Township, in central eastern Ripley Township, and in central Knox Township.

LOWER MERCER LIMESTONE

STRATIGRAPHY AND EXTENT

The Lower Mercer limestone is one of the three important limestone members in Holmes County. Although it is less steady than the Putnam Hill limestone, it is much more steady than the Upper Mercer limestone, and is a valuable stratigraphic horizon marker.

The Lower Mercer limestone in Holmes County lies on the northwestern edge of an area in the Allegheny Plateau region of Ohio which is underlain by the stratum. The bed crops out in Mahoning, Portage, Stark, Summit, Wayne, Tuscarawas, Holmes, Coshocton, Muskingum, Licking, Perry, Hocking, Vinton, Jackson, Scioto, and Lawrence counties in Ohio.[1] The member was first called the Lower Mercer limestone from exposures near Mercer in Mercer County, Pennsylvania.[2] In 1874 the name Zoar limestone[3] was given to the stratum by J. S. Newberry, but the term Lower Mercer is now uniformly used in Ohio.

The Lower Mercer member crops out in Holmes County in all townships except Washington and here it may be present at the top of one or two of the higher hills, although it was not observed. This stratum is not nearly so persistent as the Putnam Hill limestone which lies about 80 feet above. The Lower Mercer seems to weather more rapidly along road cuts than does the Putnam Hill, and slabs are not so likely to be found as float on hillsides. However, it is more likely to crop out in streams than is the Putnam Hill which is more likely to be concealed in stream valleys and gullies. The Lower Mercer is fairly persistent in Paint Township, in southwestern Prairie, and southern Monroe, in southern Berlin, in all of Walnut Creek, in southwestern Clark, throughout most of Mechanic, large parts of Killbuck, and in those parts of Rich-

[1] *Ibid.*, p. 121.
[2] Rogers, H. D., Geol. Survey of Pennsylvania, Vol. 2, pt. 1, pp. 474-477, 1858.
[3] Newberry, J. S., Report of Geol. Survey of Ohio. Vol. II, pt. I, plate opp. p. 81 and p. 130, 1874.

land except central Richland Township. Where the bed is due but not present its place is taken by shale.

The only township in which the bed is largely below the main drainage lines is Clark Township. Because of the structural influence of the Millersburg syncline the bed occurs in the central part of the county at a lower elevation than to the east or west and the usual dip in this part of Ohio to the east-southeast is not fully resumed until the southeastern corner of the county is reached. In the western part of the county the Lower Mercer is retained to a much greater extent than would be possible if the hills were not considerably higher than in the central part of the county.

The thickness of the Lower Mercer limestone ranges in Holmes County from 1 foot to 7 feet 2 inches. At most outcrops the thickness is between 2 and 4 feet. An average of 61 measurements of the thickness of this stratum is 2 feet 10½ inches. (The figure 3 feet 2 inches given on the "Average Section" on the Geologic Map includes the overlying ore). The stratigraphic position of the bed is about halfway between the top and the bottom of the Pottsville formation of the Pennsylvanian system. On the average the Lower Mercer limestone lies 82 feet 8 inches below the Putnam Hill limestone. An average of 39 measurements where the Upper Mercer coal is absent gives 24 feet ½ inch as the interval to the Bedford coal, but the average is 27 feet where the Upper Mercer coal is present. No significant horizon markers are present in Holmes County between the Lower Mercer limestone and the base of the Pottsville, although at places the massive Massillon sandstone occupies a large part of this interval. On the average, the Lower Mercer limestone lies 8 feet 7½ inches above the Flint Ridge coal, and 23 feet 1 inch above the Lower Mercer coal. The interval from the base of the Lower Mercer limestone to the Harrison ore—the basal member of the Pottsville—is variable. Measurements ranging from 67 feet to 134 feet were obtained but an average of 10 direct measurements gives 97 feet 4 inches as the interval from this limestone to the base of the Pottsville.

The Lower Mercer limestone is fairly steady in thickness and characteristics over considerable areas in Holmes County. At most exposures this marine stratum is a moderately dark blue-gray, hard, somewhat crystalline, fossiliferous limestone. The color may range from a very dark blue to a fairly light bluish gray. This bed is popularly known throughout the county as the "Blue Lime." The stratum may locally be confused with the Putnam Hill limestone but it can generally be distinguished from the Putnam Hill on the basis of the darker blue color, the more granular texture, the less tendency to weather into plates, which the Putnam Hill shows, and the somewhat more massive character. As detailed sections show, the member at most exposures consists of two or three massive layers. The upper few inches of the Lower Mercer limestone is commonly somewhat argillaceous and ferruginous, and a few inches of a true iron ore is sometimes found on top of the limestone. At some places along the outcrop of the stratum in Ohio the bed is somewhat flinty but in Holmes County flinty characteristics in this limestone are present at only a few locations.

Paint Township.—The horizon of the Lower Mercer limestone in Paint Township is above drainage in all except the extreme southwestern part. The stratum crops out only in the southern part along the north side of the valley of Indian Trail Creek. Outcrops of bedrock are largely concealed in the central and northern parts of the township by the covering of glacial drift. Inasmuch as the limestone is present north of Paint Township, Holmes County, in Sec. 17, Paint Township, Wayne County, less than 2 miles north of the county line,[1] it may reasonably be assumed to be present in northern Paint Township, Holmes County, at some places where due beneath the drift.

In the southwestern part of Paint Township the Lower Mercer limestone crops out in the bed of a small stream tributary to Indian Trail Creek, one-half mile east of Easley School, at an elevation of about 1,090 feet. One mile east of Easley School and 1 mile northwest of Trail, along a north-south road, the limestone is exposed near the bottom of a valley of another tributary to Indian Trail Creek (6-205, Appendix). Just north of the Paint-Walnut Creek township line, one-quarter mile north of the village of Trail, the Lower Mercer limestone is exposed along the road bank of the Trail-Winesburg road at an altitude of 1,076 feet. Here the limestone, which is hard, blue, dense, and fossiliferous, is 1 foot 8 inches in thickness and its base 13 feet 6 inches below the base of the overlying Upper Mercer coal (7-199).

One and one-half miles east of Trail the marine stratum under discussion crops out three-eighths mile north of Kalb Church along the road south of Indian Trail Creek. The limestone presents a typical appearance and is 3 feet 2 inches in thickness. Its position is 92 feet 4 inches below the base of the Putnam Hill limestone (9-196). A little less than one-quarter mile east of the Holmes-Tuscarawas county line and one-quarter mile south of Indian Trail Creek, in Wayne Township of Tuscarawas County, the Lower Mercer limestone is 3 feet 6 inches in thickness and has an elevation of 1,050 feet (10-198).

The Lower Mercer limestone is present where due elsewhere in western Wayne Township of Tuscarawas County, showing the usual characteristics.

Salt Creek Township.—The horizon of the Lower Mercer limestone is due over most of Salt Creek Township but it crops out only in the southwestern corner of the township. This part of the county is drift

[1] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, pp. 103, 104, 1921.

covered and whether the stratum under discussion is present but concealed by the drift, or whether its place is taken by sandstone and shale, is not known. The Lower Mercer limestone is poorly exposed in the bottom of a small ravine in SE¼SW¼ Sec. 31 at an elevation of about 1,100 feet. The bed is present along the north-south road 1 mile south of Martinsville at the Prairie-Salt Creek township line at an altitude of approximately 1,110 feet. Here 1 foot of hard, dark, fossiliferous limestone is visible, but this doubtless is not the full thickness of the bed (14-13, Appendix). This limestone is 74 feet 9 inches below the base of the Putnam Hill limestone and 6 feet 3 inches above the underlying Flint Ridge coal.

Prairie Township.—The horizon of the Lower Mercer limestone is present in Prairie Township only on hills in the southeast and central western parts. It was not seen in the northeastern part, where its place is believed to be taken by sandstone and shale. A small area of the limestone is present in the southeastern corner between Colliers Run and Martins Creek (21-48).

The limestone is due along the hillsides in the central southern part of Prairie Township between Paint Creek and Killbuck Creek but its place is taken by sandstone and shale. The Lower Mercer limestone is present in central western Prairie Township underlying an area of about 2 square miles which extends into Ripley Township to the west. The outcrop along the road between central S Sec. 31 and central N Sec. 6, three-fourths mile east of the Ripley-Prairie township line, at an elevation of 1,110 feet, is not clear enough for measurement. The characteristics of the limestone and associated beds in NW¼SW¼SE¼ Sec. 7 are shown by the following section measured along the road:

	Ft.	In.
Shale, siliceous, and slightly ferruginous	15	0
Limestone, dark blue, hard, dense to slightly granular, fossiliferous, *Lower Mercer,* altitude, 1,130 feet	2	6
Shale, carbonaceous; and covered, *Middle Mercer* coal horizon	1	0
Clay, siliceous, shaly	3	6

Ripley Township.—The horizon of the Lower Mercer limestone in Ripley Township remains uneroded in the central and southern part. In central eastern Ripley Township, in SW¼SW¼SE¼ Sec. 1, the bed crops out along the road, where 1 foot 1 inch of limestone is overlain by thin, shaly, calcareous iron ore (20A-353, Appendix). The Lower Mercer is fairly persistent in central Ripley Township. In NE¼SW¼ Sec. 34 the character of the bed is shown by the following data secured along the road just south of a small stream tributary to Shreve Creek:

	Ft.	In.
Clay, light, siliceous, *Bedford*	1	8
Ore, sandy, somewhat micaceous	0	10
Shale, sandy	9	2
Limestone, dark blue, dense, hard, fossiliferous, *Lower Mercer,* altitude 1,180 feet	4	8
Clay and covered, *Middle Mercer*	5	0

One-half mile northwest the Lower Mercer limestone is exposed along the road at an elevation of approximately 1,160 feet. No exposures of the limestone were seen in southern or southwestern Ripley Township. In southwestern Ripley Township the horizon appears to be occupied by sandstone.

Washington Township.—The Lower Mercer limestone was not seen in Washington Township. Its horizon has been removed by erosion except from the high land 2 miles west of Nashville, in E½ Sec. 15, but no outcrops were seen.

Knox Township.—A considerable part of Knox Township has sufficient elevation to retain the horizon of the Lower Mercer limestone. It is due along the sides of the east-west ridge which was the main preglacial divide in northern Knox Township, high up on Kaylor Ridge in the southwestern portion, and along the sides of Bell Ridge in the eastern part. In northeastern Knox Township the horizon of the Lower Mercer limestone is occupied by massive sandstone. In the central eastern portion the bed under discussion crops out at several places in ravines on the western side of Bell Ridge. In a ravine 1 mile south of Stone School and one-eighth mile west of the 1,303-foot road fork, the Lower Mercer member consists of one massive ledge of dark blue, fossiliferous limestone 3 feet and 1 inch thick, overlain by 2 inches of shaly limestone. Here it lies 63 feet 3 inches below the base of the Putnam Hill limestone and 123 feet 3 inches below the base of the Middle Kittanning coal, which has been stripped on the hill above (26-324, Appendix). About 1 mile south of this locality, one-quarter mile northwest of Bell Ridge School, the Lower Mercer limestone is shaly and 1 foot 8 inches thick (27-271).

In central Knox Township, 3 feet of Lower Mercer limestone is exposed along a road at the top of the ridge 2½ miles south of Nashville, one-eighth mile east of partial Sec. 13 (30-320).

Near the top of Kaylor Ridge in secs. 15 and 16, a little less than a mile east of the Knox-Holmes county line, a small outlier of Lower Mercer limestone has an elevation of approximately 1,290 feet (29-333). The Lower Mercer limestone is believed to be present at an altitude of approximately 1,260 feet along that part of Kaylor Ridge south and east of Germany School because of outcrops just south of Knox Township in Richland Township. The limestone has a thickness of more than 3 feet near the top of the east-west ridge along the Knox-Richland township line 2 miles northwest of Glenmont (32-318).

Monroe Township.—The Lower Mercer limestone underlies much of Monroe Township. In the northwestern portion of the township it is replaced by sandstone and in the southeastern part it is apparently absent because of lack of deposition. The marine stratum is believed to underlie most of the high land in eastern Monroe Township at an altitude of about 1,080 feet. To the southeast of Paint Valley outcrops are obscured by glacial drift. Farther south in the eastern part of the township, where the drift is thinner, the limestone is exposed at an elevation of 1,085 feet along an abandoned road 1 mile north-northeast of the hamlet of Welcome, where the stratum, 3 feet 6 inches in thickness, is hard, dark blue, quite crystalline, and rather fossiliferous (39-248, Appendix). The interval from the base of the limestone to the base of the overlying Putnam Hill limestone, which crops out near the top of the hill to the northeast, is 83 feet. One mile southeast of this locality, one-half mile east-northeast of Philips School, the Lower Mercer limestone was penetrated in a water well drilled on the farm of Homer Doty by John McMillan, who reported "blue limestone," 5 feet in thickness, 87 feet below the "gray" or Putnam Hill limestone (40-280).

In the southeastern corner of Monroe Township, southeast of Philips School, and south of the glacial boundary, the Lower Mercer limestone horizon is occupied by shale. The member is present in southern Monroe Township southwest of Welcome, cropping out near the Killbuck-Monroe township line at an altitude of approximately 1,130 feet, and presenting no significant differences from the characteristics and thicknesses mentioned above. In the northwestern central part of the township the bed is present with only a few wants. One mile east-southeast of Phinney School and 2¼ miles northwest of Welcome, the beds measured along an east-west road are as follows:

	Ft.	In.
Shale, siliceous and ferruginous	10	0
Limestone, blue, hard, dense, fossiliferous, somewhat platy, *Lower Mercer*	2	8
Shale, carbonaceous; and covered, *Middle Mercer*, altitude 1,145 feet	1	0
Clay, and covered	5	0
Clay shale, and covered	10	0

At places along the valley of a southward-flowing tributary to Black Creek one-quarter mile east of the Knox-Monroe township line, in the region to the west and southwest of Birds School, sandstone has replaced the limestone. At the north end of this valley, however, the Lower Mercer limestone has not been replaced. In a ravine one-eighth mile east of Knox Township and 2½ miles north of Richland Township, the limestone is 3 feet 5 inches in thickness (34-324A). In an adjacent ravine, one-half mile east of the Knox Township line and 2¼ miles north of the Richland Township line, the Lower Mercer limestone crops out boldly as a solid ledge, 4 feet 1 inch in thickness, of gray-blue to blue, fine, granular, fossiliferous limestone, lying 24 feet below the flinty Upper Mercer limestone, (35-358A).

Hardy Township.—Killbuck Creek and its tributaries have trenched their valleys 200 feet or more below the horizon of the Lower Mercer limestone in Hardy Township. The member is due at elevations ranging from 1,020 to about 1,100 feet, but throughout most of the township its place seems to be occupied by shale. At the base of the water tower in the northeastern portion of Millersburg, loose blocks of Lower Mercer limestone lie at an elevation of approximately 1,020 feet, but the bed, in place, is not visible. The limestone underlies the high land in the northwestern part of Hardy Township in the vicinity of Gambles School (51-242, Appendix).

Berlin Township.—The horizon of the Lower Mercer limestone underlies most of Berlin Township. The headwaters of Doughty Creek, Martins Creek, and of Sand Run have cut their valleys below the horizon of the member, but elsewhere the bed is below drainage. Outcrops along Martins Creek in Berlin Township are masked by glacial deposits—kames and kame terraces. Outcrops are present only in the southern part of Berlin Township in the valley of Doughty Creek and in the headwaters of Sand Run. South of Berlin, in the general vicinity of Wise School, the Lower Mercer is from 3 to 4 feet in thickness and has an elevation of approximately 1,060 feet. In a small gully just west of the north-south road 1 mile north of Wise School, the Lower Mercer limestone crops out as one massive ledge, 3 feet thick, underlain by 3 inches of shaly Middle Mercer coal. Here the limestone is 93 feet 8 inches below the base of the Putnam Hill limestone which crops out farther up the road to the north (71-45, Appendix). One-quarter mile east of this exposure and 1½ miles south of Berlin, the limestone has a thickness of 4 feet (72-46).

From one-half to 1 mile south of Wise School the Lower Mercer limestone keeps its usual character and thickness, cropping out at an elevation of approximately 1,060 feet. In a ravine just north of the road in NW partial Sec. 23, the thin, shaly, ferruginous layers overlying the 4 foot main ledge of the Lower Mercer are well exposed. Here also the Lower, Middle, and Upper Mercer coals, ordinarily extremely thin or wanting in Holmes County, show exceptional development (68-60).

Walnut Creek Township.—The Lower Mercer limestone underlies all of Walnut Creek Township except where it has been eroded by Walnut Creek and its tributaries, and by Indian Trail Creek. It crops out persistently near the lower part of the valley walls. The limestone is believed to have once been continuous over the whole township, as there is no evidence of replacement by sandstone or of lack of deposition. On either side of Indian Trail Creek the bed has a thickness of nearly 2 feet and crops out at an elevation of approximately 1,060 feet, where its stratigraphic position is about 90 feet below the Putnam Hill limestone (7-199, 76-200, Appendix). Farther up Trail Creek to the west the bed has the same character and reaches a thickness of a little more than 3 feet.

A little less than 1 mile east of the Holmes-Tuscarawas county line in Wayne Township, Tuscarawas County, the Lower Mercer limestone crops out at an elevation of approximately 1,055 feet on the north side and at 1,045 feet on the south side of Walnut Creek Valley. The stratum has the same characteristics as it has to the west in Walnut Creek Township and is 87 feet below the base of the Putnam Hill limestone, one-quarter mile north of Germany School (75-197).

In NW Sec. 7, Walnut Creek Township, Holmes County, the Lower Mercer limestone is present along the road at an elevation of about 1,020 feet. In SW Sec. 4, just southeast of Switzerland School, the limestone is typical in appearance and lies at the same altitude. At the head of the first tributary to Walnut Creek north of Goose Creek, one-half mile north of Walnut Creek village, the Lower Mercer limestone is 3 feet 1 inch in thickness, and lies 97 feet below the Putnam Hill limestone (79-216).

Along Goose Creek, an eastward-flowing tributary to Walnut Creek in the south central part of the township, good exposures are found in ravines and road cuts. In this valley the bed consists of 2 to 3 feet of hard, dark-blue, granular, fossiliferous limestone whose elevation ranges from 1,005 feet along the road near the junction of Goose and Walnut creeks to 1,035 feet 1¼ miles northwest of the village of Walnut Creek.

In SW¼ Sec. 20, 3 feet 6 inches of typical blue Lower Mercer limestone crops out at an elevation of 1,015 feet along the state road just south of Walnut Creek village, where it lies 19 feet below the Upper Mercer limestone and 90 feet below the Putnam Hill limestone (88-106).

Where exposed along the road in the southeastern part of the township in NE¼SW¼ Sec. 25, at an elevation of 1,020 feet, the bed has a typical appearance and thickness (93-134). At this place the interval is 60 feet 8 inches between the base of the Lower Mercer limestone and the overlying Putnam Hill limestone. An interesting feature here is the presence of 3 feet 1 inch of shaly Middle Mercer coal directly under the Lower Mercer limestone. The limestone has been quarried for local use for agricultural purposes in central Sec. 21, where it has a thickness of more than 3 feet, cropping out at an altitude of 1,015 feet.

The Lower Mercer limestone passes under cover in the valley of the west branch of Walnut Creek in the southwestern portion of the township, about one-half mile southwest of Mast School. The marine stratum is well exposed one-half mile northeast of Mast School, in NE¼NE¼ Sec. 23 just west of a road fork, where it is darker blue than usual, very hard, almost flinty, very fossiliferous, and occurs in one bed 3 feet thick at an elevation of 1,010 feet. Its position is 92 feet below the Putnam Hill limestone, which crops out along the road up the hill to the west (83-99).

Clark Township.—The Lower Mercer limestone in Clark Township is below drainage except in a very small area in the headwaters of Walnut Creek in Sec. 2 in the central northern part; at the headwaters of a tributary of Doughty Creek in the vicinity of Charm in the northwestern corner; in the heads of two small tributaries to Doughty Creek in the central western part; in the headwaters of Mill Creek in the central western part; and in the headwaters of Mill Creek in the southwestern corner. This bed is believed to be rather generally present under cover in Clark Township because of the steadiness in Walnut Creek Township to the north, in the western part of Clark Township, and in Mechanic Township to the west, and in Crawford Township, Coshocton County, which adjoins it on the south.

No outcrops of the limestone were observed in Sec. 2 in the central northern part of Clark Township in the headwaters of Walnut Creek, the stratum at this horizon being obscured by silt and wash in the valley bottom; but its presence immediately to the north indicates that it is probably present in this part of Clark Township. In the northwestern part of the township the limestone crops out in a small ravine just east of the road along the line between Mechanic and Clark townships in NW¼SW¼NW¼ Sec. 5. The limestone, whose full thickness is not exposed, has an elevation of about 1,040 feet, and is 92 feet 8 inches below the Putnam Hill limestone which crops out farther up the hill to the south (121-83). Three-fourths of a mile northwest of Charm, in SE¼NW¼ Sec. 5, the limestone is 3 feet 6 inches in thickness (102-62) in the west bank of a stream.

On the northeast side of the stream the limestone is exposed along the road from central Sec. 5 to Charm, a distance of one-half mile, at an elevation of approximately 1,030 feet. It passes under cover at an elevation of about 1,040 feet at the southern edge of the village, where it is 1 foot 6 inches in thickness and is underlain by 3 inches of bony to canneloid Middle Mercer coal. Where a road leading west from Charm crosses the stream, the limestone has the same thickness and elevation and is 27 feet below the Upper Mercer flinty limestone which crops out up the road to the west (103-88, Appendix). Near Charm the Lower Mercer limestone has been occasionally dug from the banks and bottom of the stream and burned for agricultural lime. It is not as satisfactory for this purpose as the Putnam Hill limestone, consequently the latter is more used even though it must be hauled from outcrops 1 or 2 miles away.

The position and character of the Lower Mercer in the central western part of the township is known from outcrops in SW Sec. 15 (106-262) and in NW (107-261) and central Sec. 16.

At the headwaters of Mill Creek in central and northern Sec. 16, the Lower Mercer crops out near the valley bottom at an elevation of approximately 1,010 feet, but no clear sections suitable for measurement are found in this locality. In SW¼SW¼NW¼ Sec. 16 the limestone has been quarried at the road fork, and one or two small kilns burned for agricultural lime (107-261).

Farther down Mill Creek in the southwestern corner of Clark Township, in SE¼NW¼ Sec. 25, the Lower Mercer limestone lies about 990 feet above sea level where it is exposed along the road east of the cross-road (109-186). The member crops out along the county line road 1 mile west of New Bedford at an elevation of approximately 1,010 feet. It presents no departures from the characteristic appearance and thickness.

As noted above, the Lower Mercer does not crop out in the central or southeastern part of Clark Township. However, the Lower Mercer horizon is exposed 1 mile south of this township in Crawford Township, Coshocton County, where the White Eyes Creek drainage has cut well below the level reached by the northward-flowing Sugar Creek drainage which drains most of Clark Township. In a ravine just east of the north-south road 1 mile south of the Holmes-Coshocton county line 1⅛ miles west of the Tuscarawas-Coshocton county line, the Lower Mercer limestone has the following thickness and character:

	Ft.	In.
Shale, clay-like to sandy	10	0
Limestone, dark blue, hard, fossiliferous, *Lower Mercer,* altitude 1,050 feet	3	8
Coal, fossiliferous, bony, *Middle Mercer*	0	6

Farther south of Holmes County in Crawford Township, Coshocton County, and in Bucks Township, Tuscarawas County, and still farther south, the Lower Mercer limestone is much thicker, much more steady, and much more commonly present in the stratigraphic column than in Holmes County to the north and northwest. In localities where the bed is markedly thicker it would be expected to be more persistent. The limestone is well exposed at several places along the West Lafayette-Baltic-Sugar Creek state road in eastern Crawford Township (119-167).

Mechanic Township—The Lower Mercer limestone is the most useful stratigraphic horizon marker in Mechanic Township, because in central and southern Mechanic Township the land surface has been rather generally eroded below the horizon of the Putnam Hill limestone. The Lower Mercer is present where due, except in a small area in the northwestern corner of the township.

In the northeastern part of Mechanic Township, the Lower Mercer limestone crops out on either side of the valley of Doughty Creek at an elevation of from 1,040 to 1,050 feet. In the vicinity of Troyers Mill, in NE¼NE¼ Sec. 10, the member presents its usual appearance and is about 3 feet 6 inches in thickness, underlain by 2 to 4 inches of shaly Middle Mercer coal (123-82, Appendix). Its position is 93 feet below the Putnam Hill limestone. A small amount of the limestone has been quarried for agricultural lime in a gully on the east side of Doughty Creek at Troyers Mill. In NW¼NE¼ Sec. 1, the limestone is well exposed in a gully south of the road, where the thickness is 3 feet 10 inches (122-78).

In central and S Sec. 2 and N Sec. 9, south of Deetz School, the Lower Mercer limestone crops out at an elevation of about 1,080 feet. The interval between the Lower Mercer limestone and the overlying Putnam Hill limestone is much shorter than average in this part of the township (126-112).

In partial Sec. 13, south of Military Run, loose pieces of hard, dark-blue Lower Mercer limestone lie at an altitude of 1,050 feet where the north-south road crosses the top of the hill in central Sec. 13. The bed is not sufficiently exposed for measurement of the thickness, but data secured show that the limestone is 22 feet above the Lower Mercer coal and 90 feet above the base of the Pottsville (138-259).

In the west central part of Mechanic Township the limestone underlying the ridge between Bucks Run, Doughty Creek, and Military Run is somewhat thinner than average, ranging from 1 foot to 2 feet 2 inches in thickness. In the bank along the north side of the gravel road 1 mile south-southwest of Webster Hall School and one-quarter mile east of Bucks Run, the limestone is present at an altitude of 1,010 feet. The main bed is 2 feet 2 inches thick, slightly flinty, is overlain by 1 inch of calcareous ore, and underlain by 1 foot 9 inches of carbonaceous shale representing the Middle Mercer coal horizon. Three-quarters of a mile to the northwest the thickness of the limestone is 1 foot and that of the underlying Middle Mercer coal 2 inches. Less than a mile to the north, the limestone is 3 feet in thickness (129-39).

Farther south along Bucks Run the characteristics and relationships of the limestone, where it crops out along the east-west road one-quarter mile east of Bucks Run and 2 miles south of Grade, are shown by the following observations:

	Ft.	In.
Shale, sandy		
Coal blossom, *Bedford*	0	6
Covered	6	0
Shale, sandy and ferruginous	20	0
Limestone, blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,010 feet	4	4
Coal smut, *Middle Mercer*	0	2
Clay, impure	1	0
Shale	3	0

In the central western part of Mechanic Township, the limestone crops out at an elevation of approximately 940 feet in SE¼NW¼SW¼ Sec. 11 in a lane just north of the road. The full thickness was not observed here, but the limestone exhibits the usual color and texture. In SW¼SE¼ Sec. 12 the limestone is underlain by an unusual thickness of carbonaceous shale—the Middle Mercer coal horizon (136-5).

In the southeastern part of Mechanic Township the limestone dips rapidly to the east from an elevation of 1,090 feet in SE Sec. 19 to an elevation of 1,010 feet in central Sec. 21. Gullying in an abandoned part of a relocated road in SE¼NE¼ Sec. 22 has exposed 2 feet 8 inches of Lower Mercer limestone at an elevation of 1,043 feet (139-264).

In the eastern parts of secs. 21, 20, and 11, along the eastern border of the township, the Lower Mercer limestone crops out at elevations ranging from 1,010 feet to 1,020 feet with no marked deviation from the usual character or from the average thickness.

Killbuck Township.—The Lower Mercer limestone is generally present where due in Killbuck Township. It has been eroded from the central part of the township by Killbuck, Black, and Wolf creeks. In the northeastern part of the township, north of Killbuck Creek, 2 feet of hard, heavy, slightly granular, grayish-blue, fossiliferous limestone crops out in a ravine, north of an abandoned road in NW¼SW¼ Sec. 4 (140-294, Appendix). Where the Pottsville strata crop out along the road in central Sec. 5, the place of the Lower Mercer limestone is taken by shale. In NE Sec. 1, shale also occupies the horizon of the Lower Mercer.

In the northwestern corner of Killbuck Township the Lower Mercer is exposed near the hilltop in N Sec. 3 at an elevation of approximately 1,130 feet, but no clear sections suitable for measurement are present.

In the central western part of Killbuck Township a small outlier of Lower Mercer limestone is present near the top of the ridge in S Sec. 8 and extends into Sec. 7 of Richland Township to the west. The bed rises from an elevation of 1,140 feet in SE Sec. 8 to 1,160 feet at the township line. The stratum is so close to the hilltop that no outcrops showing the full thickness can be found. Loose limestone blocks seen on the surface show that the rock is hard, dense, bluish, and very fossiliferous. Its stratigraphic position here is approximately 120 feet above the base of the Pottsville (143-299).

In the southwestern corner of Killbuck Township, generally poor outcrops of Lower Mercer limestone were observed at an elevation of about 1,140 feet in SW Sec. 21. The limestone is 2 feet 3 inches in thickness in NW¼SE¼ Sec. 23, where many large blocks are conspicuous in the ravine below the outcrop of the bed (144-345A). The interval between the Lower Mercer and Putnam Hill limestones is 66 feet.

The largest area of Lower Mercer limestone in Killbuck Township lies in that part of the township south and east of Killbuck Creek. In a ravine near the road in NW¼NE¼ Sec. 13, the member is 3 feet 3 inches thick, cropping out at an elevation of 1,020 feet (148-31).

No outcrops of the limestone were observed in secs. 14 and 17, and its place is probably taken by shale. In E½ Sec. 18, near the Killbuck-Mechanic township line, the Lower Mercer limestone crops out at several places along the road. The limestone is above the average in thickness, reaching 5 feet or more (153-76).

In the southeastern corner of the township, the limestone in Sec. 23 is of about average thickness and is normal in character. Along the road in NE¼SW¼ Sec. 23 it lies 63 feet below the Putnam Hill limestone (154-77). The altitude of the Lower Mercer is approximately 1,015 feet.

Richland Township.—Scattered outliers of Lower Mercer limestone are found well up near the tops of the hills in northeastern Richland Township, on Kaylor Ridge in the northwestern part of the township, along the flanks of the southern part of French Ridge in the central southern part of the township, and near the tops of the hills southeast of Wolf Creek in the southeastern portion. The limestone, which is due well below the top of French Ridge in the central part of Richland Township, has been replaced by sandstone. In the northeastern part of Richland Township, north of Black Creek, the limestone lies near the tops of the hills in Sec. 4 and Sec. 5, at an altitude of approximately 1,175 feet. Along the section line road between NE Sec. 5 and NW Sec. 4, the Lower Mercer is 4 feet 1 inch thick and lies at an altitude of 1,177 feet. The interval from the Lower Mercer to the Quakertown coal is 84 feet and from the limestone to the base of the Pottsville, 119 feet. The Lower Mercer is here 30 feet 4 inches below the overlying Bedford coal (157-268, 269, Appendix). The thickness and character of the limestone and its relationship to the Harrison ore—the basal member of the Pottsville—are shown in a ravine and along a road in SE¼SW¼NW¼ Sec. 4 as follows:

		Ft.	In.
Clay shale, with small ore balls		2	0
Ore, nodular; and covered		0	6
Limestone, gray blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,175 feet		3	3
Clay and covered		3	0
Sandstone, irregular; and covered	*Massillon*	38	9
Sandstone, massive	*Massillon*	35	0
Ore, impure, sandy, *Harrison*		0	6
Sandstone, thin-bedded to 1-foot beds, *Waverly*		40	0

The Lower Mercer limestone underlying that part of Kaylor Ridge in northwestern Richland Township is thin but very persistent. In this locality it is somewhat thinner bedded and more shaly than usual (158-359). The overlying Upper Mercer limestone in this part of the township is not nearly so flinty as usual and closely approximates the Lower Mercer in appearance.

The elevation of the Lower Mercer limestone rises in central Sec. 3 to 1,250 feet and the member is argillaceous and fossiliferous. In Sec. 4 the interval from the Lower Mercer limestone to the Upper Mercer limestone is 33 feet, an increase in that found to the east (161-380). The limestone has a thickness of about 3 feet (162-379). Along the southern part of Kaylor Ridge west and northwest of Baddow Pass the Lower Mercer limestone was not observed; its horizon is apparently occupied by shale.

Along French Ridge in the central part of the township the Lower Mercer limestone is apparently absent from the section, but in the central southern portion of the township the Lower Mercer reappears. Along the Holmes-Coshocton county-line road in SW Sec. 22 and in SE Sec. 23, the Lower Mercer is represented by 7 feet 2 inches of calcareous shale and the overlying Lower Mercer ore is 1 foot thick, the thickest noted in Holmes County (168-374).

In the southeastern corner of the township the member crops out in NW¼SW¼ Sec. 24 at an elevation of 1,140 feet in a road ditch, but its full thickness is not exposed (169-340).

ECONOMIC VALUE

The Lower Mercer limestone is above drainage in every township in Holmes County, but it is not everywhere present where due. It has an average thickness of 3 feet 2 inches. Because the Putnam Hill limestone, which lies above the Lower Mercer, is more persistent, is somewhat thicker, tends to have a higher carbonate content, and crops out nearer the tops of the hills, it has been much more extensively quarried than the Lower Mercer. Small quarrying operations in the Lower Mercer limestone have been carried out from time to time in Mechanic and Clark townships and the stone burned for agricultural lime, for which use it was satisfactory. Occasional pieces of the limestone with a somewhat higher silica content are conspicuous after burning because they do not slake readily and are discarded. The lime has a darker color than lime from the Putnam Hill member. The Lower Mercer has seldom been ground for agricultural purposes, as has the Putnam Hill, but it is suited for that purpose. It should provide satisfactory stone for road building.

No analyses of the Lower Mercer limestone from Holmes County are available, but the member was sampled in 1941 by R. E. Lamborn on the Boyd property, just south of the road in central Sec. 6, White Eyes Township, Coshocton County, where the stone was being quarried in a ravine.[1] The stone from the quarry was used for road metal. It is usable for agricultural purposes, but is dark and hard and does not give as white a crushed product as is preferred by farmers. A section of the beds is as follows:

	Ft.	In.
Shale, black, soft	2	6
Limestone, black, hard; with white fossils; one bench, *Lower Mercer*	3	2
Shale, black; and coal, shaly, *Middle Mercer*	0	6
Clay, dark, plastic	1	0

[1] Information on the Lower Mercer limestone in Coshocton County was kindly furnished by Mr. R. E. Lamborn from notes and manuscript for a forthcoming bulletin of the Geological Survey of Ohio on "Coal Measures Limestones."

The analysis, GSO No. 340, by Downs Schaaf, is as follows:

Silica, SiO_2	3.11
Alumina, Al_2O_3	1.40
Ferric oxide, Fe_2O_3	0.02
Ferrous oxide, FeO	1.55
Pyrite, FeS_2	0.23
Magnesium oxide, MgO	1.14
Calcium oxide, CaO	49.95
Strontium oxide, SrO	<0.01
Barium oxide, BaO	<0.01
Sodium oxide, Na_2O	0.02
Potassium oxide, K_2O	0.10
Water, hydroscopic, H_2O-	0.24
Water, combined, H_2O+	0.40
Carbon dioxide, CO_2	41.36
Titanic oxide, TiO_2	0.07
Phosphorus pentoxide, P_2O_5	0.07
Sulphur trioxide, SO_3	0.09
Manganous oxide, MnO	0.19
Carbon, organic, C	0.07
	100.01

LOWER MERCER ORE

The Lower Mercer ore in Holmes County is of no economic importance and of very little stratigraphic importance. It was formerly mined in parts of southern Ohio for the making of iron in charcoal furnaces, but such use was never made of it, nor indeed of any of the Pennsylvanian iron ores in Holmes County.

In this county the Lower Mercer ore, if present, lies directly on the Lower Mercer limestone. The usual thickness is from 1 to 2 inches. The ore is shaly, calcareous siderite, which on the outcrop has been weathered to limonite. The greatest thickness of this member in Holmes County is in southwestern Richland Township, at the Holmes-Coshocton county line in SE¼ Sec. 23 and SW¼ Sec. 22, where 1 foot of irregular nodular ore overlies 7 feet 2 inches of calcareous shale which represents the Lower Mercer limestone at this place (168-374). The character, thickness, and position of the ore is illustrated in the sections which include the Lower Mercer limestone. The ore is of no importance stratigraphically aside from its association with the Lower Mercer limestone, so no detailed sections of the ore alone are presented.

UPPER MERCER COAL

STRATIGRAPHY AND EXTENT

Between the Lower Mercer limestone and the Upper Mercer limestone and flint two coals are found. The first coal lying above the Lower Mercer limestone is called the Upper Mercer coal, and the next coal above, which lies directly under the Upper Mercer limestone and flint where it is present, is the Bedford coal. The Upper Mercer coal is at all continuous only in the northeastern part of Holmes County, in southern Paint Township and in northern and north central Walnut Creek Township. Elsewhere in the county there is commonly no coal between the Bedford coal and the Lower Mercer limestone, this horizon being occupied by shale. However, from place to place thin scattered lenses of coal, or of carbonaceous shale representing a coal horizon, lie between the Bedford coal and the Lower Mercer limestone. These are called the Upper Mercer coal. The Upper Mercer coal horizon, almost everywhere represented by a hard, carbonaceous shale, has an average thickness of 1 foot 3 inches. The greatest thickness of carbonaceous shale observed at this horizon in the "main field" of northeastern Holmes County is 3 feet 2 inches. The average thickness is less than 2 feet. Most of the small discontinuous deposits in the other parts of the county are less than a foot in thickness.

On the average, the Upper Mercer coal lies 16 feet 8 inches above the base of the Lower Mercer limestone and 10 feet 2 inches below the Bedford coal. The Upper Mercer coal is underlain by thin, very impure clay. Between the Upper Mercer clay and the Lower Mercer limestone, shale, commonly clay shale, is present. Between the Upper Mercer coal and the Bedford clay, shale, generally somewhat siliceous, is found.

In the northeastern part of Holmes County the Upper Mercer coal everywhere consists of hard, carbonaceous shale, generally in one bed. At one or two places, however, the carbonaceous shale is in two benches separated by 2 or 3 inches of clay shale. Elsewhere in the county the Upper Mercer coal horizon is at most places a carbonaceous shale, although at one or two localities several inches of coal is present.

Paint Township.—In Paint Township the Upper Mercer coal is present in the southern part of the township, where outcrops are found along the valley of Indian Trail Creek and its tributaries. It is present between the Lower Mercer limestone and the Bedford coal, generally appearing just a few feet below the overlying Bedford. In the central and northern parts of Paint Township outcrops at this horizon are obscured by glacial drift and no data are at hand to indicate either its presence or character.

In the southeastern corner of the township, south of Indian Trail Creek, the Upper Mercer coal crops out at an altitude of approximately 1,060 feet along the road which is on the township line, one-half mile north of Kalb Church, three-fourths mile west of the Tuscarawas County line. At this locality, the coal consists of 1 foot 2 inches of carbonaceous shale, underlain by 3 feet 6 inches of impure, sandy clay. The coal is 11 feet below the Bedford coal and 18 feet 8 inches above the base of the Lower Mercer limestone (9-196, Appendix). In the central southern part of Paint Township, just north of the Walnut Creek-Paint township line and one-quarter mile north of Trail, the Lower Mercer coal and its relationship to the Lower Mercer limestone are shown where the beds crop out along the bank of the Walnut Creek-Trail-Winesburg road. The record secured here follows:

		Ft.	In.
Shale, sandy		5	0
Shale, hard, black, bone	Upper Mercer coal	1	1
Clay shale, gray	Upper Mercer coal	0	3
Shale, hard, black, bone	Upper Mercer coal	0	4
Clay, impure; and covered		2	0
Clay shale, gray, some dark streaks		9	10
Limestone, hard, blue, dense, fossiliferous, *Lower Mercer*		1	8
Coal smut, clay and covered		1	0
Clay, gray, light, plastic		5	4
Shale, sandy		20	4
Shale, siliceous		22	8
Covered		16	0
Crossroad, altitude 1,011 feet.			

One mile west-northwest of the above section the Upper Mercer coal horizon crops out along an abandoned road, at an altitude of 1,135 feet, where the horizon is occupied by 1 foot of hard, carbonaceous shale, lying 5 feet 10 inches below the Bedford coal and 15 feet above the base of the Lower Mercer limestone (6-205).

The Upper Mercer coal is apparently absent from the section in Salt Creek, Prairie, and Ripley townships. The rocks at this horizon have been removed by erosion from Washington Township.

Knox Township.—The Upper Mercer coal is generally absent from the stratigraphic column in Knox Township. However, in the eastern part of the township 1 mile south of Stone School in a ravine which heads 100 yards south of the 1,303-road fork one-half mile west of the Monroe Township line, carbonaceous shale 4 feet 5 inches thick, cropping out at an altitude of 1,225 feet, represents the Upper Mercer coal horizon. This carbonaceous shale is 5 feet 8 inches below the base of the Bedford coal and 14 feet 7 inches above the Lower Mercer limestone (26-324, Appendix). In an adjacent ravine one-half mile northwest the Upper Mercer is a true coal 5 inches in thickness, overlain by 7 inches of black canneloid shale, lying 10 feet 2 inches below the Bedford coal (25-396). Elsewhere in the township no coal or carbonaceous horizon was seen between the Lower Mercer limestone and the Bedford coal.

Monroe Township.—The Upper Mercer coal horizon is a carbonaceous shale at many exposures in Monroe Township, but is only of stratigraphic interest. In the eastern central part of the township 1 mile north-northeast of Welcome the strata are exposed along an abandoned road, where a few inches of carbonaceous shale crops out at an elevation of 1,110 feet, 23 feet above the Lower Mercer limestone and 8 feet below the Bedford coal (39-248). Along the north-south road 1½ miles north-

northwest of Welcome and three-fourths mile south of the Loudonville-Millersburg state road the Upper Mercer coal is represented by 7 inches of carbonaceous shale underlain by 1 foot 6 inches of very hard, sandy, micaceous clay (38-322). The coal crops out at an elevation of approximately 1,150 feet. At this place the Bedford coal is 6 feet above the Upper Mercer. In some ravines in western Monroe Township carbonaceous shale at the Upper Mercer horizon is present (35-358A).

Hardy Township.—In Hardy Township the interval between the Lower Mercer limestone and the Bedford coal is occupied by shale.

Berlin Township.—In Berlin Township, although the Upper Mercer coal is generally absent, it seems to be present in a few places in the southwestern corner of the township (68-60).

Walnut Creek Township.—The Upper Mercer coal is found in the northern, the central, and the southwestern parts of Walnut Creek Township. It is absent because of lack of deposition in the southeastern part. This area of Upper Mercer coal in Walnut Creek Township is a part of that area in Paint and Walnut Creek townships which is the largest continuous area of Upper Mercer coal in Holmes County.

One-half mile southeast of Trail, exposed along a road, the Upper Mercer coal is carbonaceous shale occurring in two benches separated by clay shale (76-200).

Two miles west of Trail and one-half mile south of the Paint Township line the Upper Mercer coal horizon crops out just north of a roadfork at an elevation of 1,075 feet, where it consists of 3 feet 2 inches of hard, black, carbonaceous shale lying 9 feet under the Bedford coal (80-219). In the central part of the township, about midway between Trail and Walnut Creek villages, the Upper Mercer coal horizon, represented by carbonaceous shale, is exposed in road ditches and in ravines at an altitude of about 1,060 feet.

In the south central part of the township, in the vicinity of Walnut Creek village, the Upper Mercer coal is absent. It reappears in the southwestern part of the township, being represented by carbonaceous shale where it crops out along the east-west road in NE¼ Sec. 23 (83-99).

Clark Township.—The horizon of the Upper Mercer coal is below drainage in all of Clark Township except the extreme western part, where the horizon under discussion is generally occupied by shale. In the northwestern part near Charm a hard, black, bone shale, locally present below the Bedford coal, represents the Upper Mercer coal horizon. At the roadfork in NW¼NW¼ Sec. 7, one-quarter mile southeast of Charm, 1 foot 2 inches of black bone shale, exposed at an altitude of 1,045 feet and lying 5 feet below the Bedford coal, represents the Upper Mercer coal horizon (104-90, Appendix). In the southwestern portion of the township, in the valley of Mill Creek, as much as a foot of shaly

Middle Mercer coal lies about 15 feet below the Bedford coal. The underlying Upper Mercer clay is everywhere thin and impure.

Mechanic Township.—No outcrops of the Upper Mercer coal were seen in Mechanic Township, and it appears to be absent because of lack of deposition.

Killbuck Township.—The Upper Mercer coal is absent in most of Killbuck Township. However, in the central northern part the Upper Mercer coal horizon is represented by 7 inches of carbonaceous shale in NE¼ Sec. 1, cropping out at an altitude of about 1,060 feet. This carbonaceous shale contains many plant fossils and lies 12 feet below the thin Bedford coal and 65 feet below the Putnam Hill limestone (142-285).

In the southwestern part of Killbuck Township the Upper Mercer coal is 9 inches in thickness and of very shaly character in NW¼SE¼ Sec. 23, where its position is 16 feet above the base of the Lower Mercer limestone and 6 feet 5 inches below the Bedford coal, which is overlain by the Upper Mercer flinty limestone (144-345A). In NW¼NE¼ Sec. 22 the member consists of 1 foot of interbedded coaly shale and shale (145-368).

Richland Township.—The data at hand indicate that the Upper Mercer coal is absent through lack of deposition in Richland Township.

ECONOMIC VALUE

Because the Upper Mercer coal in Holmes County is almost universally a carbonaceous shale, it is of no value for fuel purposes. At several places in the vicinity of Trail, in northern Walnut Creek Township and southern Paint Township, the weathered outcrop of this horizon appears to be a coal blossom, but everywhere on a fresh outcrop the material is carbonaceous shale. As far as the writer is aware, no attempts have been made to mine this material.

The clay underlying the Upper Mercer coal is thin, impure, and valueless.

BEDFORD COAL

STRATIGRAPHY AND EXTENT

The Bedford coal bed which lies below the Upper Mercer limestone is the most valuable source of fuel in the Pottsville formation in Holmes County. It is present in all the townships of the county and has been mined in at least a few localities in practically every one. Although the bed lacks sufficient extent, thickness, and purity ever to be a very important source of fuel for large-scale mining operations, it constitutes a valuable reserve and present source of fuel for local household use. The bed is very persistent throughout the county, being absent in only a few places. It is much more continuous than the black, flinty Upper Mercer limestone whose normal position is just above the Bedford coal.

The interval between the Putnam Hill limestone and the Lower Mercer limestone is ordinarily divided into three units of about the same thickness. At about the base of the upper division is the very persistent, but thin Tionesta coal; at the base of the middle division is the Bedford coal. On an average the Bedford coal lies 55 feet 8 inches[1] below the Putnam Hill limestone, 28 feet 9 inches below the Tionesta coal, and 24 feet ½ inch (27 feet where the Upper Mercer coal is present) above the base of the Lower Mercer limestone. In a few places in Holmes County the Upper Mercer coal is present between the Lower Mercer limestone and the Bedford coal. An average of the interval between the Bedford and Upper Mercer coals in these localities gives a figure of 10 feet 2 inches. A few direct measurements of the interval between the Bedford coal and the Harrison ore and the distance between the Bedford coal and the Quakertown coal were secured. An average of the former is 117 feet and of the latter is 110 feet.

The Bedford coal is normally overlain by black, flinty Upper Mercer limestone, but at more than half the outcrops in the county this overlying limestone is missing, and its place is taken by calcareous, fossiliferous shale, or by clay shale, or locally by siliceous shale. The material between the Bedford coal and the Tionesta coal, aside from the flinty limestone, is generally siliceous shale grading upward into sandy or shaly sandstone. Where sandstone is present over the Bedford coal it is commonly shaly sandstone which passes downward into shale, rather than coarse, massive sandstone indicative of erosion and later deposition. However, in small areas in Richland and Ripley townships the massive Homewood sandstone appears to replace the Bedford coal.

The coal ranges in thickness from a minimum of less than 1 foot to a maximum of 11 feet 5 inches. The mean of the measurements of the Bedford coal in Holmes County, including partings, is 3 feet 1 inch. The Bedford coal is ordinarily separated into two benches by a thick parting located near the middle of the member. The better quality coal is found in the upper bench at some localities, and it is found in the lower bench at others. Locally the bed is cut into more than two parts by shale partings. Although these partings may be clay-bonded sandstone, generally the parting or partings are shale. Both benches of the coal are somewhat shaly at many places and at not a few places one or both benches are really carbonaceous shale rather than true coal. Some cannel coal appears on this horizon but its presence is restricted and it is not nearly so common as the cannel coal in the Bedford member to the south in Coshocton County.

The Bedford coal can be traced from Holmes County southward into the main field in Bedford Township, Coshocton County, from which locality the member takes its name. In the type locality in Coshocton

[1] The average of 34 direct Putnam Hill-Bedford measurements is 50 feet 1 inch.

County the bed is partly or wholly cannel coal of excellent quality and good thickness, which has in the past supported railroad mining operations. The cannel character of the coal dies out rapidly north of Bedford Township, Coshocton County, and is almost entirely lost in central Holmes County. On the other hand, the cannel character of the coal continues much farther to the south and in Muskingum County the coal is partially a cannel coal.[1]

The clay underlying the Bedford coal is thin and impure at most outcrops. Its average thickness throughout the county is 3 feet but it is usually less than this figure rather than more, at some places being a few inches and at other localities being absent almost entirely. The greatest thickness of Bedford clay measured is 6 feet 2 inches.

Paint Township.—The Bedford horizon is due over much of Paint Township. Outcrops are generally concealed by glacial drift in the northern part of the township, but at some places the coal is of minable thickness. It was formerly mined in NE Sec. 33, where the following section was measured by Conrey.[2]

		Ft.	In.
Limestone, gray, *Putnam Hill*		5	0
Interval		43	6
Flint	*Upper Mercer*	2	0
Limestone, dark blue, fossiliferous	*Upper Mercer*	4	0
Coal, good	*Bedford*	1	0
Coal, cannel	*Bedford*	0	5
Clay	*Bedford*	0	1
Coal	*Bedford*	1	0
Clay, light, plastic		4	0

Attempts have been made to mine the Bedford coal in NE¼NW¼-NE¼ Sec. 36, but no sections suitable for measurement could be found (1-228, Appendix). In this section, the coal is about 35 feet below the Putnam Hill limestone.

In the southeastern part of the township in one or two locations the Bedford coal has fair thickness, as indicated by the following data (see also 9-196, Appendix) secured in a ravine one-fourth mile west of the Tuscarawas-Holmes county line and 1 mile north of Indian Trail Creek just north of a road:

		Ft.	In.
Weathered clay, with a few blocks of black, fossiliferous flint, *Upper Mercer*		2	0
Coal, fair	*Bedford,* altitude 1,100 feet	1	2
Shale, dark, carbonaceous	*Bedford,* altitude 1,100 feet	0	¾
Coal, fair	*Bedford,* altitude 1,100 feet	1	5
Clay, impure		3	0

[1] Stout, Wilber, Geology of Muskingum County: Geol. Survey Ohio Bull. 21, p. 93, 1918.
[2] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, p. 106, 1921.

In the southwestern part of the township the Bedford coal seems to be of poor quality and generally less than 2 feet in thickness. Along the north-south road one-half mile north of the Paint-Walnut Creek township line and 1 mile NW of Trail at an altitude of 1,135 feet, the Bedford coal is 1 foot 2 inches thick, of poor quality (6-205), and is underlain by a foot 10 inches of impure clay.

Salt Creek Township.—In Salt Creek Township the Bedford coal is of fair quality and reaches minable thickness at several places in the north central and in the western parts. The Bedford coal in the western part of Salt Creek Township is part of a larger area which also underlies eastern and southeastern Prairie and northeastern Hardy townships, constituting the largest and most important field of the Bedford coal in Holmes County. The horizon of the Bedford coal in northeastern Salt Creek Township is concealed by glacial drift.

In the central part of the township along a road in central Sec. 3 a blossom of the Bedford coal, 1 foot 6 inches thick, is underlain by 2 feet of sandy, impure clay (15-236, Appendix). The interval from the base of the Bedford coal to the base of the overlying Putnam Hill limestone, which has been quarried in a field, is 44 feet 3 inches. To the north the coal is thicker and is mined one-quarter mile west of Guthrie School in NE¼NW¼NE¼ Sec. 33 (11A-327).

In the central western part of Salt Creek Township the Bedford coal is of fair thickness and has been mined in several places. In central Sec. 6, the Bedford coal, overlain by flinty Upper Mercer limestone, crops out at an altitude of approximately 1,140 feet. The coal here reaches a maximum thickness of approximately 3 feet 6 inches (13-59). No fresh sections were noted for detailed measurements. In SW¼ Sec. 31, the coal is reported to be 2 feet 9 inches thick and to be overlain by 2 feet of Upper Mercer limestone.

In the southwestern corner of Salt Creek Township the Bedford coal lacks the Upper Mercer limestone and flint roof but its characteristics are in general the same as those shown in the adjacent corner of Prairie Township, which are mentioned below.

Prairie Township.—Although the Bedford coal in Prairie Township underlies a small area, its thickness is generally above average. It has been mined near the hilltops in the southeastern part of the township, in the eastern, the northeastern, and central southern portions. These areas were once part of a continuous field in Salt Creek, Prairie, and Hardy townships.

In the extreme southeastern corner of Prairie Township the Bedford coal crops out at an elevation of approximately 1,100 feet. A few yards north of the Hardy-Prairie township line and one-half mile west of the Prairie-Salt Creek township line, just west of a road forks, the Bedford coal was formerly mined. The bottom of the coal is not exposed in the old mine so the thickness of 5 feet measured is probably less than the total thickness of the coal. The coal is rather bony and no doubt burns with a high residue of ash. Here the coal is overlain by 3 feet of partially flinty Upper Mercer limestone (47-51).

One mile to the northwest, three-eighths mile south of Hammond School, in partial Sec. 14, 3 feet 6 inches of weathered coal is overlain by 1 foot of hard, dark-blue, flinty, fossiliferous Upper Mercer limestone (20-47). The base of the Bedford coal is 30 feet above that of the underlying Lower Mercer limestone. The Bedford clay at this locality is above the average in quality and consists of 3 feet of light, plastic clay. No openings into the coal appear to have been driven in this locality and a considerable amount of coal may be present in this partial Sec. 14. One-half mile east, in the western part of partial Sec. 13, the coal has been mined from an opening in the farm of Albert Arnold just west of the north-south road. The character and thickness of the Bedford coal and of the overlying Upper Mercer limestone are shown in the following section secured at the mine mouth:

		Ft.	In.
Limestone, blue, hard, fossiliferous, partially flinty; flint is black, hard, and fossiliferous, *Upper Mercer*		2	0
Coal, bony	*Bedford*	0	6
Coal, good	*Bedford*	3	1
Coal, bony	*Bedford*	0	5
Shale, black bone, hard	*Bedford*	1	4
Clay, siliceous		3	0

In Sec. 1 in the central eastern part of Prairie Township, the Bedford coal is now being or has been mined from several openings in the central and northeastern parts of the section, where coal is exposed near the top of a ridge at an altitude of approximately 1,120 feet. The Bedford coal here is not divided into benches by shale partings as it is generally. The carbonaceous, shaly material and bony coal seem to be confined to the upper and lower portions of the bed, the central part being fairly good coal. The coal is overlain by the Upper Mercer limestone, which is somewhat less flinty than in most places throughout Holmes County. Because the limestone is near the top of the hill it has been partly dissolved by ground water. Small solution channels, really miniature caves 1 foot or more high, are found at the bottom of the limestone. The overlying limestone, partly dissolved by ground water, is called "honeycomb rock" by the miners. Locally these cavities are partly or wholly filled with clay. Because the coal is so close to the top of the hill the blocks of coal are likely to be stained with rusty-colored iron oxide, but the coal itself has not been weathered enough to affect its burning qualities. The coal is underlain by clay-bonded sandstone rather than by clay. The character of the coal and of the material overlying it are shown by the following section measured in the local mine of G. H. Zehnder in central Sec. 1. For the results of the analysis of the sample taken here see under "Economic Value":

			Ft.	In.
Limestone, blue, hard, very fossiliferous, slightly flinty; (up to 4 feet reported), *Upper Mercer*			2	0
Coal, bony to shaly	Bedford		0	9
Coal, good			2	10
Shale, dark, moderately hard			1	10
Coal, bony			0	6
Sandstone (reported).				

The Bedford coal, reported to be 30 inches thick, was mined many years ago on the farm of O. B. Lytle in NE¼SE¼SW¼ Sec. 36. The roof was poor, blocks of limestone often falling in entries and rooms.

In the northeastern part of Prairie Township in central Sec. 25 the Bedford coal crops out in a ravine at an elevation of approximately 1,110 feet. The full thickness of the coal is not exposed, but coal of fair quality was formerly mined from an opening in the side of the ravine and its thickness is believed to be at least 2 feet 6 inches. It is overlain by 3 feet of hard, dark-blue, flinty Upper Mercer limestone (16-54). Its base is 41 feet below the base of the overlying Brookville coal, which has been mined higher up in the ravine.

The Bedford coal has been removed by erosion from the western part of Prairie Township except from possibly a small area in Sec. 6, but here glacial drift conceals the bedrock.

In the central southern portion of Prairie Township a small area of Bedford coal remains uneroded in secs. 15 and 16 and in an area which extends to the south into Hardy Township. The coal has been mined from two openings near the road in the southeastern corner of Sec. 16 but these have long since been abandoned. According to reports the roof was bad, the drainage of the mine poor, and water interfered with mining operations. The coal consists of two benches from 1 foot to 1 foot 6 inches in thickness separated by about 1 foot of clay shale. At its best the coal here is of only fair quality. Its base lies 53 feet below that of the overlying Putnam Hill limestone (19-238). The clay beneath the Bedford coal in this part of Prairie Township is very thin and impure.

Ripley Township.—The horizon of the Bedford coal has been removed by erosion in the northern and southern portions of Ripley Township. In the central portion of the township the bedrock at this horizon is thickly covered by glacial drift. In the southwestern part the horizon of the Bedford coal is occupied by massive sandstone. In central S Sec. 1, three inches of weathered coal, at an elevation of approximately 1,160 feet, crops out in the road ditch and is overlain and underlain by rather coarse sandstone. The coal here is 13 feet 5 inches above the base of the overlying Lower Mercer limestone (20A-353, Appendix).

At most places in the southwestern part of the township, the horizon of the Bedford coal is taken by massive sandstone. However, coal formerly mined from an opening in W Sec. 7 near the top of a knob is believed to be Bedford. This mine has fallen in and it is impossible to secure measurements.

Knox Township.—The horizon of the Bedford coal in Knox Township is confined to the east-west ridge in the northern part of the township, to Bell Ridge in the eastern part, and to a very small area in the central southern part. Elsewhere it has been removed by erosion. Throughout most of the township the Bedford is carbonaceous shale or is composed of thin layers of coal of poor quality separated by a considerable thickness of shale, but at one or two localities the coal almost reaches minable thickness and quality. The member under discussion, exhibiting the two benches separated by thick partings and its relationship to the overlying Putnam Hill limestone, is exposed in a ravine just west of the 1,303-foot road fork 1 mile SSE of Stone School and one-half mile west of the Monroe Township line, on the western side of Bell Ridge, where the following section was secured (see also 26-324, Appendix):

		Ft.	In.
Limestone, gray, dense, *Putnam Hill*		1	7
Coal, good, mined, *Brookville*		2	0
Covered		35	0
Clay shale, gray		1	0
Coal, bright, good, *Tionesta?*		0	9
Clay, sandy		0	11
Sandstone, thin-bedded, clay-bonded		1	6
Shale, carbonaceous, sandy	*Bedford*, altitude 1,230 feet	0	5
Clay shale, pyritiferous		0	8
Coal, shaly		0	4
Coal, fair to bony		0	5
Clay, light, siliceous		1	3

One mile south of the above locality and one-quarter mile north of Bell Ridge School, in a ravine just northwest of a road fork, the Bedford member consists of 4 feet 2 inches of dark, carbonaceous shale which is somewhat sandy, lying 21 feet 4 inches above the base of the underlying Lower Mercer limestone (27-271). No part of the Bedford here is fitted for fuel purposes.

The horizon of the Bedford coal underlies the high ridge which trends east and west, south of Stone School and Jance School. Coal of minable thickness and quality may be present in very small amount, as many years ago the coal was mined in a small way. In the west branch of the head of the ravine which parallels Bell Ridge, one-half mile south of Stone School, 2 miles south-southeast of Nashville, and 1 mile from the Monroe Township line, the Bedford coal is 1 foot 6 inches in thickness and in part cannel coal. Upper Mercer flint overlies the coal (25-396).

A very small area of Bedford coal not over a foot in thickness is present along the Knox Township line 1½ miles northwest of Glenmont. This is an outlier of a larger area to the south and southwest in Richland Township which is discussed under "Richland Township."

Monroe Township.—The Bedford member is widely distributed in Monroe Township, can generally be found where due, and is of minor importance for fuel purposes. Its character and relationship to the overlying beds are shown along the road which follows the boundary line between Monroe and Hardy townships, one-half mile south of the Loudonville-Millersburg road, where the following data were secured:

	Ft.	In.
Limestone, loose pieces, *Putnam Hill*		
Clay and covered, *Brookville*	5	0
Shale, sandy to siliceous	15	6
Coal, shaly, *Bedford,* altitude 1,160 feet	0	10
Clay, impure	3	0
Clay shale, gray	9	8
Sandstone, irregular, light	3	0
Covered	11	0
Sandstone, massive	22	0

In the central northern part of the township, the coal at many places has a fair thickness and lacks the usual partings, as shown in the following section measured along the state road three-fourths mile northeast of Phinney School and 100 yards west of the 1,144 foot road fork:

		Ft.	In.
Clay, siliceous		3	0
Coal, good	*Bedford,* altitude 1,200 feet	1	7
Coal, shaly		0	3
Clay, siliceous		2	3
Sandstone, light, clay-bonded, ganister		2	0
Shale, sandy.			

In the extreme western part of the township, the coal is of fair quality and has been mined in a small way. A cannel coal bed lying under massive Homewood sandstone, formerly mined just west of a road 1 mile south of the Ripley Township line and one-half mile east of the Knox Township line, may be Bedford. In a ravine just south of an east-west road, one-fourth mile east of the Knox-Monroe township line and 1¼ miles northeast of Bell Ridge School, 1 foot 2 inches of Bedford coal crops out, overlain by 6 inches of Upper Mercer black flint. Here the Bedford coal is 15 feet 3 inches above the base of the underlying Lower Mercer limestone (34-324A). One-half mile southeast of this exposure, the Bedford coal has been mined near the bottom of a ravine one-half mile east of the Knox Township line and 2⅛ miles north of the Richland Township line, where 3 feet 9 inches of black, flinty Upper Mercer limestone overlies the coal. The coal is reported to be in part cannel, 2 feet 10 inches in thickness, with two 1-inch partings within the bed (35-358A). Coal believed to be Bedford was formerly mined from an opening, now fallen in, on the farm of John Armstrong one-half mile west of Birds School in the southwestern part of the township. No outcrop was observed but the coal was reported to be in two benches each about 2 feet thick and separated by from 4 to 20 inches of hard ganister. The roof was spoken of as a "slate" roof. The upper bench of the coal is of far higher quality than the lower and was mined almost entirely, the lower bench not being taken.

Although no good measurements were secured in the southwestern part of the township, the Bedford coal reaches a fair thickness three-fourths mile north of the Richland Township line and 1¼ miles east of the Knox Township line, where the coal was formerly mined from an opening, now fallen in, just south of the east-west road. As exposed along the east-west road one-fourth mile west of the crossroad, whose elevation is 1,190 feet, 1 mile southwest of Welcome, the Bedford coal is present but thin. This outcrop may not represent the full thickness and under cover the coal may be as much as 1 foot thick. Here the Bedford coal lies 81 feet below the base of the overlying Putnam Hill limestone (37-255).

In the central part of the township the characteristic division of the bed into two parts separated by a 4-inch parting is well exposed along the north-south road seven-eighths mile south of the state road and 1½ miles north-northwest of Welcome (38-322). The total thickness of the member is 1 foot 9 inches.

Hardy Township.—The Bedford coal crops out at many places in Hardy Township. It has been removed by erosion from the valleys of Killbuck Creek and its tributaries but considerable areas are left underlying the higher land. In the northern and northeastern parts of the township, its thickness is well above the average and, although much coal has been removed from the local mines, a considerable quantity still remains. In the southwestern part of the township the coal reaches the greatest thickness observed at any place in Holmes County.

In the northeastern part of the township, the Bedford coal is part of a field which originally extended over eastern Prairie and western Salt Creek townships and which constitutes the most important area of Bedford coal in Holmes County. The coal has been mined in SW¼ NW¼SW¼ Sec. 4 on the farm of H. J. Gindelsberger, where the upper bench is of much greater thickness and higher quality than the lower bench. As in most of this field, the coal is overlain by the Upper Mercer limestone which makes a very satisfactory roof. The thickness of the various parts of the Bedford member and of the underlying clay are recorded as follows:

			Ft.	In.
Limestone, *Upper Mercer* (not full thickness)			2	0
Coal, bony, very pyritiferous	*Bedford*		0	6
Coal, good	*Bedford*		2	1
Shale, hard, bony, black	*Bedford*		0	7
Shale, dark, but not bony	*Bedford*		1	2
Coal, shaly, poor, not mined	*Bedford*		0	7
Clay, dark, impure			1	0
Clay, light, plastic			2	0

To the northwest, near the Prairie-Hardy township line, the Bedford coal may reach a thickness of 5 feet, but it is of poor quality, although it has been mined from one or two openings (47-51).

The Bedford coal has been mined on the farm of B. A. Findley from an opening on the north edge of the road one-quarter mile west of the 1,128 foot road fork, which is just west of SW partial Sec. 5. The following details of the coal strata were measured in the mine and the beds above exposed along the road to the road fork, where the Putnam Hill limestone crops out:

		Ft.	In.
Limestone, gray, blocks and tilted ledges, *Putnam Hill*		15	0
Coal and covered, *Brookville*, altitude 1,128 feet		1	0
Clay, light gray; poorly exposed		12	0
Shale, sandy; and sandstone, shaly; poorly exposed		16	0
Covered		27	4
Limestone, dark blue, flinty; (full thickness not seen)	*Upper Mercer*	1	6
Limestone, very dark blue black, fossiliferous	*Upper Mercer*	0	4
Shale, dark blue, calcareous, fossiliferous		0	½
Coal, fair	*Bedford*	0	4
Bone shale, (left up for roof, except in entry)	*Bedford*	0	5
Coal, good; discontinuous pyrite bands	*Bedford*	0	9½
Bone coal and shale, pyritiferous	*Bedford*	0	3½
Pyrite	*Bedford*	0	¼
Coal, good	*Bedford*	0	9½
Shale, black, hard	*Bedford*	0	1
Coal, fair, very hard	*Bedford*	0	11
Coal, bony	*Bedford*	0	2
Clay, dark, hard, impure.			

In the northern part of Hardy Township west of Killbuck Creek, several openings in the Bedford coal have been driven but none of these very far because of the poor quality or inadequate thickness of the coal. In this part of the township the Upper Mercer limestone is absent. One-quarter mile northwest of Oak Ridge School a blossom 1 foot thick is believed to represent the Bedford coal. The coal is probably thicker under cover. In the central western part of the township, the member is thin and shaly and openings into the bed have been disappointing. The full thickness of the Bedford coal is not exposed one-half mile south-southeast of Gambles School, but its stratigraphic position lies 28 feet above the base of the Lower Mercer limestone and 58 feet below the Putnam Hill limestone (51-242).

In the southwestern corner of Hardy Township, the Bedford coal reaches its maximum thickness in Holmes County. As is generally true, where the Bedford coal is thicker than average, it is the upper bench of the coal which thickens so markedly. The coal was formerly mined from an opening known as the "Leasure" (or sometimes as the "Shevilard") mine, in the headwaters of Hardy Run, three-sixteenths mile north of the Killbuck Township line and 1⅛ miles east of the Monroe Township line. A small amount of the material was shipped to Mt. Vernon and used for the extraction of coal oil. Some was also shipped to the Cleveland Gas Company. The upper bench of the coal in this mine consists of 7 feet of impure canneloid coal with some thin lenses of true cannel coal (54-290). One-eighth mile west, the Bedford coal is replaced by sandstone as discovered in core drilling (55-401).

In the southeastern part of Hardy Township the total thickness of the Bedford member is considerable but the proportion of actually good coal is small, because the benches are separated by a thick shale parting (59-9).

Although no outcrops of Bedford coal were seen in eastern Hardy Township east of Millersburg, coal of minable thickness is reported from this part of the township by Read, who says,[1] "Elias Mast's mine, in Hardy Township, east of Millersburg, has a firm limestone roof, admitting of chambers fifty to eighty feet wide, timbered only along the railways; coal hard, bright, and of good quality." The following section at this mine is given by Read:

1.	Limestone	4 feet
2.	Coal	18 to 20 in.
3.	Fire-clay	8 in.
4.	Coal	2 ft. to 2 ft. 10 in.
5.	Black shale	20 in.
6.	Cannel coal	1 ft.

Berlin Township.—The Bedford coal underlies all of Berlin Township except where it has been removed by erosion from the valleys of Doughty and Martins creeks and from the headwaters of Sand Run. Outcrops of this and other beds are obscured in the northern portion of the township by thick glacial drift so that its character is known only in the southern part.

In the southwestern corner of Berlin Township, where exposed by erosion of the headwaters of Sand Run in partial Sec. 23, the Bedford

[1] Read, M. C., Report on the Geology of Holmes County: Geol. Survey Ohio Vol. 3, Pt. 1, p. 552, 1878.

coal crops out at an elevation of approximately 1,100 feet and lies 36 feet above the Lower Mercer limestone. In this locality, the Bedford coal ranges from 6 to 10 inches in thickness, is very shaly, and is underlain by thin, impure clay (68-60, Appendix). To the east the Bedford coal becomes thicker and was formerly mined for local use near the road on the farm of Kelvin Math 1½ miles northeast of Saltillo and seven-eighths mile southwest of Wise School. Here the lower bench of the coal bed contains the good coal of minable thickness. The data secured in this old mine follow:

		Ft.	In.
Shale, gray		3	0
Shale, dark, carbonaceous	*Bedford,* altitude 1,080 feet	0	3
Coal, good		0	2
Clay, gray to light		1	1
Coal, good		1	10
Clay, impure, siliceous		2	0

One mile south-southeast, along a road just north of NE Sec. 2, Mechanic Township, the Bedford coal is represented by 5 inches of shaly coal underlain by 1 foot of impure clay, at an elevation of approximately 1,100 feet, occupying a position 47 feet below the Putnam Hill limestone (70-109). In the area between Wise School and Berlin village, the thickness is generally less than 1 foot, and the coal shaly. The thin, shaly character of the coal is well exposed along the Millersburg road 1 mile west-southwest of Berlin village (67-113).

Southeast of Berlin, in the general vicinity of Miller School, the Bedford coal horizon, bearing an elevation of approximately 1,100 feet, is occupied by carbonaceous shale. In a ravine one-half mile west of Miller School the carbonaceous shale at the Bedford horizon is very hard and bony and is 2 feet 6 inches in thickness. It is underlain by shale rather than clay. One-half mile northwest of Miller School, the Bedford is extremely shaly and is divided into the usual two benches separated by a very thick parting, as shown by the following measurements secured along a road:

		Ft.	In.
Coal, shaly; and covered		1	0
Clay and covered		2	0
Shale, siliceous		5	6
Shale, carbonaceous	*Bedford,* altitude 1,100 feet	0	10
Shale, thin-bedded, micaceous, ganister		2	8
Shale, dark, carbonaceous, micaceous		0	9
Clay shale		2	0

Walnut Creek Township.—The Bedford coal horizon is well represented in Walnut Creek Township, cropping out over most of the township near the bottom of the valleys. In this township, the coal is nearly everywhere overlain by the Upper Mercer flinty limestone. The Bedford coal in Walnut Creek Township reaches a fair thickness in many places, but is usually shaly. The presence of better seams of coal—the Lower Kittanning and Middle Kittanning—has discouraged efforts at mining the Bedford, but eventually some fuel will be won from the Bedford seam.

In the northeastern part of Walnut Creek Township, the Bedford coal is thin and shaly. Along the road one-half mile southeast of Trail, the Bedford coal is 9 inches thick, and is underlain by 3 feet of impure clay. Here the Bedford coal has an altitude of 1,075 feet and is 19 feet above the base of the Lower Mercer limestone (76-200). Farther south of Trail the Bedford coal becomes thicker and the quality somewhat better. A thickness of 1 foot 7 inches is exposed just south of the crossroad 1 mile south of Trail (78-215).

A mile south of the above locality, along the road south of Hochstetler Run, 1 foot 1 inch of Bedford coal of fair quality crops out immediately below the Upper Mercer limestone (79-216). In the northwestern part of Walnut Creek Township the Bedford coal is present but is thin. At most places it is accompanied by the overlying Upper Mercer limestone. It crops out in the headwaters of Indian Trail Creek, going under cover in Sec. 3.

In the southwestern part of Walnut Creek Township the Bedford coal is very shaly, at places being a carbonaceous shale rather than a coal. At some outcrops the overlying Upper Mercer limestone is present; at most of them, however, it is absent. The following data secured along the road in SE Sec. 18 are illustrative of the character of the bed in this locality:

	Ft.	In.
Shale, siliceous to sandy	5	0
Shale, black, carbonaceous, *Bedford,* altitude 1,030 feet	1	4
Clay, siliceous	2	0

In the vicinity of Walnut Creek village the Bedford coal crops out to the north in the valley of Goose Creek and to the south in the valley of Walnut Creek, where the thickness ranges from 1 foot to 1 foot 8 inches. In this locality, the coal is everywhere shaly in character and is overlain by the Upper Mercer limestone. One mile west-northwest of the village of Walnut Creek the coal bed is partly made up of cannel coal (86-120). East of Walnut Creek village in central and NW Sec. 16, the Bedford coal is 2 feet or more in thickness but is of poor quality (90-133).

In the southeastern part of Walnut Creek Township, southeast of the valley of Walnut Creek, the Bedford coal is thicker than elsewhere in the township, and its quality is perhaps not so poor. In the SW¼NW¼ SE¼ Sec. 25, the Bedford coal is 2 feet 9 inches in thickness but of poor quality, cropping out at an altitude of 1,035 feet. Here it is 46 feet below the Putnam Hill limestone and 17 feet 4 inches above the Lower Mercer limestone (93-134). Inasmuch as the Bedford coal is mined just a little more than a mile east of the southeastern part of Walnut Creek Township at the mine of the Finzer Bros. Brick Plant, it is quite probable that Bedford coal of minable thickness and of at least fair quality underlies secs. 24 and 4 of Walnut Creek Township. Sec. 17 possibly contains minable Bedford coal but data are not at hand from this section.

Clark Township.—In Clark Township the Bedford coal is exposed only in the northern and the northwestern parts and along the western border of the township. It has been reached by a slope a short distance below the surface in the northeastern part of the township. The coal in the northeastern portion is known to be of a minable thickness and quality. That in the western part is not thick enough to mine. The character and thickness of the coal under cover in the central and southeastern parts are not known.

In the northeastern part of the township, in NE¼NE¼ Sec. 7, the coal bed has been reached by a short slope on the farm of Robert Troyer by the General Clay Products Co., which trucks the coal 4 miles to its plant in Baltic for burning drain tile. How continuous the coal is to the west is not known, but it is continuous to the north and east as known from outcrops in Walnut Creek Township to the north and from a mine of the Finzer Bros. Brick Co. in Shanesville. The structure of the Bedford coal in the General Clay Products mine is recorded as follows:

		Ft.	In.
Shale, gray, siliceous, with occasional small ovoid, gray iron concretions		4	0
Shale, dark, carbonaceous, fossiliferous, *Upper Mercer* limestone horizon		0	2
Coal, good	*Bedford,* altitude 1,010 feet	1	0
Shale, black, pyritiferous		0	⅜
Coal, good		0	4½
Shale, black, hard, fossiliferous		0	3
Coal, good		2	5
Pyrite and coaly streaks		0	1½
Clay shale, rapidly grading downward from siliceous shale to sandy shale		4	0

The coal has also been reached by a slope in central N Sec. 14, but no data are at hand as to quality or thickness.

In the central northern part of Clark Township the Bedford coal outcrops in the headwaters of Walnut Creek, where it is usually accompanied by the overlying Upper Mercer limestone. The coal is thin and shaly in SW¼SW¼ Sec. 2, being 9 inches in thickness and lying 65 feet below the Brookville coal (95-172, Appendix). Along the road between Clark Township and Walnut Creek Township in NW¼NE¼ Sec. 3, the Bedford coal has a thickness of 1 foot 9 inches, including several thick partings (85-119).

In the northwestern part of Clark Township in the vicinity of Charm the Bedford coal reaches a thickness of from 1 foot 6 inches to 2 feet, but it is shaly or bony in character (103-88).

In the central western part of Clark Township, in secs. 15 and 16, streams tributary to Doughty and Mill creeks have cut down far enough to expose the Bedford horizon at elevations ranging from 1,025 to 1,035 feet. At some places the Upper Mercer limestone is thin and at other places it is absent from the section. In this part of Clark Township the Bedford consists of from a few inches to about 1 foot of carbonaceous shale or of very shaly coal. In SW¼NE¼ Sec. 16 the Bedford coal consists of 2 feet 8 inches of somewhat shaly coal, underlain by 4 feet of an impure, very sandy clay, where it crops out at an elevation of approximately 1,060 feet along a road. Its position is 32 feet below the Putnam Hill limestone (108-185).

Mechanic Township.—The Bedford coal is widely distributed through Mechanic Township. The bed ranges in thickness from a few inches to several feet. In the northeastern part of Mechanic Township the Bedford coal is everywhere present where due but is very erratic in thickness. It is generally at least somewhat shaly. In SE¼NE¼ Sec. 1 the Bedford coal has a total thickness of 2 feet, but is in two benches separated by thick shale parting, cropping out along the road just west of the Clark Township line (121-83).

One-half mile northwest, in NW¼NE¼ Sec. 1, the Bedford coal is 3 feet 1 inch in thickness and shaly in character (122-78). At Troyers Mill in NE¼NE¼ Sec. 10, the Bedford is represented by 1 foot of coaly shale lying 46 feet above the Lower Mercer limestone (123-82). In NW¼ NE¼ Sec. 10, the Bedford consists of 11 inches of coaly shale (124-81). The shaly character of the Bedford extends to the west where, along a road in NW¼NE¼ Sec. 9, black bone shale 9 inches in thickness is exposed at the Bedford horizon at an altitude of approximately 1,090 feet in a road ditch (125-110). Here the Bedford is 71 feet below the Putnam Hill limestone and 21 feet above the Lower Mercer limestone. The Bedford coal crops out in Sec. 2 at an altitude of approximately 1,100 feet, is shaly in character, and about 1 foot in thickness. One-half mile southeast of Saltillo, along the road between secs. 2 and 3, the Bedford coal horizon is represented by 1 foot 6 inches of black shale (127-141).

In the central northern part of Mechanic Township, west of Saltillo, the Bedford coal is at most places a hard, carbonaceous shale and generally but a very few inches in thickness. Along the road one-half mile southeast of Grade and one-half mile west of Webster Hall School, 1 foot of black bone shale occupies the Bedford horizon at an altitude of approximately 1,040 feet (131-37). The base of the member is 24 feet 7 inches above the base of the Lower Mercer limestone. At several outcrops from one-quarter to 1 mile south of Webster Hall School the shaly, thin character of the Bedford persists and at none of these outcrops is the bed more than 10 inches in thickness. In the vicinity of the abandoned Methodist Church one-half mile east of Bucks Run and 2 miles north of Doughty Creek, the Upper Mercer limestone appears immediately over the Bedford coal. The coal is thin and shaly as it is to the north.

In the northwestern part of Mechanic Township, the Bedford coal increases in thickness and somewhat in purity. Near the bottom of the Sand Run Hill in NW¼NE¼ Sec. 1, just south of the Hardy Township line, several desultory attempts at mining the Bedford coal have been made. At an elevation of 1,040 feet, 3 feet 6 inches of weathered material which ranges from shaly coal to carbonaceous shale crops out along the road. Here the Bedford coal lies 58 feet below the Putnam Hill limestone which crops out up the hill to the south in a prominent ledge (133-36). In central Sec. 2, in the northwest corner of the township, the Bedford horizon is present at an altitude of approximately 1,000 feet, lying 70 feet below the Putnam Hill limestone, but the section is not well exposed (134-34). The Bedford coal was formerly mined by the Harmon Hill Coal Co., just east of the highway in NE¼NW¼ Sec. 9, where the member is a somewhat shaly cannel coal. The following section measured along the road shows the position of the Bedford coal in relation to overlying strata. The figures on thickness of coal in the mine and for the black shale roof are supplied by Dr. Wilber Stout from data secured when the mine was in operation:

		Ft.	In.
Coal blossom, *Lower Kittanning*		1	0
Covered		68	8
Limestone, *Putnam Hill*, altitude 1,085 feet		1	0
Covered		32	8
Shale, black, fissile		1	0
Coal, cannel, somewhat shaly	*Bedford*	4	2
Coal, bituminous; and shale, not good	*Bedford*	1	0
Covered		66	6
Sandstone, massive, *Massillon*		48	6
Sandstone, thin-bedded		11	4
Covered		60	4
Sandstone and covered		44	0

It is probable that coal of minable thickness remains underlying part of Sec. 9 and possibly Sec. 12 of Mechanic Township although in the latter section no clear outcrops suitable for measurements of the Bedford horizon are present. A blossom of Bedford coal 1 foot thick was noted near a road forks in SW¼ Sec. 12 at an altitude of approximately 1,070 feet (135-4). It is probable that the coal is thicker under cover.

Exposures of the Bedford coal are present at elevations just under 1,000 feet in the southwestern part of Mechanic Township. These exposures are poor but indicate that the member is shaly and thin. In the southeastern part of Mechanic Township, south of Doughty Creek, the Bedford coal is present but thin. Just north of the cross road in E½ Sec. 22, a blossom of the Bedford coal 1 foot thick crops out at an elevation of 1,048 feet, 16 feet 6 inches above the Lower Mercer limestone (139-264). Although outcrops of the Bedford coal were not seen in secs. 20 and 21 adjacent to Clark Township, from outcrops across the township line in Clark Township which show that the Bedford coal is thin and shaly, it is believed also to be thin and unimportant in these sections in the southeastern part of Mechanic Township.

Killbuck Township.—The horizon of the Bedford coal remains in the eastern, the northern, and in a bit of the southern part of Killbuck Township. It has been removed by erosion from the central and central western portions. In the northeastern part of the township, north of Killbuck Creek, the Bedford coal is found in secs. 4, 5, and 1. In secs. 4 and 5, which are just south of an area of thick, shaly cannel coal formerly mined at the Shevilard mine to the north in Hardy Township, the Bedford coal is of considerable thickness, but to the west the thickness decreases. In SW¼NE¼ Sec. 5 a blossom of shaly Bedford coal 1 foot 6 inches thick is exposed along the road at an altitude of 1,090 feet, where the coal is 48 feet below the Putnam Hill limestone (141-288). It is quite possible that the Bedford coal may be thicker under cover where it is unweathered. In NE¼ Sec. 1, the Bedford coal is reduced in thickness to 4 inches and is very shaly where it crops out along a road at an altitude of 1,085 feet, 53 feet below the Putnam Hill limestone (142-285).

In a few isolated areas in the southwestern part of Killbuck Township the Bedford coal is thin and impure. In SE¼SE¼ Sec. 22, one-quarter mile north of the Coshocton-Holmes county line, the Bedford coal is 9 inches thick and has a shaly character, as shown in an exposure along the road at an altitude of approximately 1,110 feet. The position of the Bedford coal here is 17 feet 3 inches above the Lower Mercer limestone (146-346).

The Bedford coal has its greatest thickness, best quality, and largest area in Killbuck Township in the eastern central and central eastern part of the township to the east and southeast of the village of Killbuck. In this area some Bedford coal has been removed from small mines and some remains for future exploitation. A considerable area in Sec. 14, and probably also to the north in southwestern Sec. 7, is underlain by Bedford coal of fair thickness. It was formerly mined on the farm of H. E. Leavengood just southwest of the road forks in NW¼ Sec. 14, but the mine was abandoned when a "horseback" was encountered. The thickness and structure of the Bedford coal in this mine and its relationship to the Putnam Hill limestone, which crops out just below the road forks, are shown by the following data:

		Ft.	In.
Limestone, gray, *Putnam Hill*		3	0
Covered		2	0
Clay		5	0
Covered		6	0
Shale, siliceous		13	0
Shale, gray		2	0
Shale, coaly	*Bedford,* altitude 1,090 feet	0	5
Coal		0	7
Shale, dark		0	4
Coal		2	8

In NE¼SW¼SW¼ Sec. 14, the coal is thinner as shown by the following section measured along the road:

		Ft.	In.
Shale, very sandy; with some ½-inch shaly, coaly streaks		15	0
Sandstone, thin-bedded; with coaly streaks		2	0
Coal, with sandy streaks	*Bedford,* altitude 1,100 feet	0	2
Sandstone, white, micaceous; with coaly streaks		0	3
Coal, shaly		0	9
Shale, clayey, dark		0	2
Coal		0	6
Clay, gray, impure		0	4
Shale, siliceous		0	6

In NW¼ Sec. 17 a small area of Bedford coal is present. The following section is probably representative of the bed here:

	Ft.	In.
Shale and covered	23	0
Clay shale	2	0
Coal, weathered, *Bedford,* altitude 1,110 feet	1	6
Clay and covered	4	2
Sandstone, white.		

Data illustrative of the Bedford coal in Sec. 13 are not at hand, but information from Sec. 8 to the north indicates that at some places in Sec. 13 the Bedford coal is of fair thickness. The following two sections are supplied by Dr. Wilber Stout. In central S Sec. 8, data are as follows:

	Ft.	In.
Limestone, *Upper Mercer*	4	7
Shale	2	0
Coal, cannel, reported, *Bedford*	7	0

In the central E Sec. 8 on the McDowell property, Dr. Stout measured the following section:

	Ft.	In.
Sandstone		
Shale, black, fissile	1	0
Coal, cannel and bituminous, *Bedford*	0	11
Shale, dark	0	8

In the southeastern part of the township, in Sec. 18, the Bedford coal is exposed at an altitude of approximately 1,020 feet. It is thin and shaly, lying about 62 feet below the Putnam Hill limestone. In a gully in NE¼SE¼ Sec. 18, the Bedford coal consists of 11 inches of fair quality cannel coal underlain by 1 foot of carbonaceous shale (152-75). To the south in Sec. 23, the horizon of the Bedford coal is at an altitude of approximately 1,025 feet, where it lies 50 feet below the Putnam Hill limestone. No clear outcrops of the Bedford were seen, but from field indications it is believed that the Bedford is thin and unimportant in this section.

Richland Township.—Areas of Bedford coal are mostly small and scattered but are widely distributed throughout Richland Township. The quality and thickness of the coal are quite diversified, at some places being but a thin smut streak, and at others being thick enough for mining in a small way. In the northeastern part of the township, north of Black Creek, the high land in secs. 4 and 5 is underlain by Bedford coal. It was formerly mined from two openings, both now fallen in, one on the farm of A. C. Hunter where the thickness is reported as 3 feet and another on the farm of William Hall's heirs. Near these old mines, along the road between NW Sec. 4 and NE Sec. 5 the Bedford coal crops out with a thickness of 2 feet (157-268, 269, Appendix.).

In the northwestern part of Richland Township, Bedford coal underlies the higher part of Kaylor Ridge. In NE¼NE¼ Sec. 3, the Bedford coal is very close to the top of the hill and is much weathered. It crops out along the township line road at an elevation of approximately 1,260 feet and is 8 inches thick. Here the underlying clay is thick—6 feet 2 inches—and is somewhat siliceous and much purer than most Bedford clay in Holmes County. The coal increases in thickness to the west in secs. 3 and 4 and the thickness of the underlying clay is reduced. Along this part of Kaylor Ridge, the Bedford coal is overlain by black, flinty Upper Mercer limestone (160-361).

In NE¼ Sec. 4, although the Bedford coal has a fair thickness, no attempt at mining the bed has been made. The coal is only fair in quality and probably under cover clay partings separate the bed into several benches (161-380). Farther south along Kaylor Ridge the Bedford coal becomes considerably thinner and very impure, in some places being a shale, as noted in SW¼NW¼ Sec. 7. The record secured in a road ditch follows:

	Ft.	In.
Sandstone, white, shaly, micaceous, clay-bonded	12	6
Shale, carbonaceous, *Bedford,* altitude 1,235 feet	1	1
Clay, impure; poorly exposed	4	6
Sandstone and covered.		

South of the Pennsylvania Railroad and east of Baddow Pass, the Bedford coal is overlain by the Upper Mercer limestone which is unusually thick and argillaceous at some places. In Sec. 13 hard, black, carbonaceous shale about 1 foot 6 inches in thickness represents the Bedford coal (164-364). To the south, in Sec. 18, the horizon of the Bedford is due at an elevation ranging from 1,215 to 1,225 feet but no good outcrops are present. The Bedford coal is undoubtedly present under cover. Still farther south, in Sec. 23, the Bedford coal, somewhat under 2 feet in thickness and usually accompanied by the overlying Upper Mercer limestone, is present at an altitude of approximately 1,215 feet. Along the county-line road in SW¼SW¼ Sec. 22, 1 foot 6 inches of weathered Bedford coal crops out below the flinty Upper Mercer limestone at an elevation of approximately 1,210 feet. Here the coal is 31 feet 9 inches above the Lower Mercer limestone and 38 feet 5 inches below the Putnam Hill limestone (168-374).

Along French Ridge, particularly in the southwestern part in the vicinity of Election School, the Bedford coal is of a somewhat higher quality than it is in most parts of Richland Township and is of sufficient thickness to have been mined in a small way in the past. The position of the Bedford coal here is very close to the Putnam Hill limestone, being generally about 35 feet below it. The character and thickness of the coal in W½ Sec. 19 are shown by the following data secured along a road:

		Ft.	In.
Sandstone, light, shaly, clay-bonded		22	0
Shale, sandy, ferruginous; and covered		12	10
Clay shale, gray	*Bedford*	1	6
Coal, weathered	*Bedford*	0	6
Clay shale, gray	*Bedford*	1	2
Clay shale, dark	*Bedford*	0	6
Coal, shaly, weathered	*Bedford*	1	2
Clay, gray, plastic; not full thickness		1	0
Covered		26	4
Crossroad, altitude 1,195 feet.			

In NW¼NE¼ Sec. 19, one-fourth mile north of Election School, Bedford coal was formerly mined on the farm of George W. Brown, who reports that the coal burns well, but is very tender. The mine is no longer worked and has now fallen in, but the following measurements are reported by Mr. Brown:

		Ft.	In.
"Slate."			
Coal	*Bedford*	1	10
"Fire clay," varied to 1 foot	*Bedford*	0	6
Coal	*Bedford*	1	10

Across the section line to the north, in SE¼SE¼ Sec. 12, 1 foot 7 inches of weathered Bedford coal is present, lying but 23 feet 3 inches below the Putnam Hill limestone—an unusually short interval between the Bedford and Putnam Hill members (167-309). One-quarter mile to the northeast, just north of a crossroad, in the bank of the road between NW¼SW¼ Sec. 11 and NE¼SE¼ Sec. 12, the Bedford coal has the following structure:

		Ft.	In.
Shale, sandy		3	0
Coal, weathered	*Bedford,* altitude 1,230 feet	0	7
Clay shale, gray		0	3
Coal, shaly		1	1
Clay		2	0
Sandstone, white, irregular		10	0

The Bedford coal continues with about the same character through Sec. 11, but in the vicinity of Fort Fizzle in NE¼ Sec. 11 and in secs. 10 and 6, the coal increases in thickness. It was formerly mined on the farm of Ellen Bussey from an opening on the line between NE¼ Sec. 11 and SE¼ Sec. 10, where the coal lies at an altitude of approximately 1,220 feet. It is reported that the coal was about 30 inches thick with a 6-inch shale parting in about the middle of the bed. The burning qualities of the coal are said to be poor. In SW¼NW¼ Sec. 6, 1 mile southeast of Glenmont, a mine has been opened in the Bedford coal from which some clay has also been extracted. The structure and character of the Bedford members in this mine are as follows:

		Ft.	In.
Clay shale, blue gray, reported		14	0
Clay shale, with ore balls to 4 inches		1	2
Coal, fair	*Bedford,* altitude 1,220 feet	0	3
Sandstone, hard, white, with plant fossils		0	4
Clay, soft, some plant fossils		0	6
Coal, good		0	11
Shale, pyritiferous		0	½
Coal, good		0	10
Clay shale, carbonaceous		0	6
Coal, bone, somewhat canneloid		0	4½
Clay, light, plastic, siliceous; reported		4	8

In the northern part of Sec. 15 (eastern part of township), the Bedford coal, from 1 to 2 feet in thickness, crops out at several localities at elevations ranging from 1,210 feet to 1,220 feet. Here the Bedford coal is underlain and overlain by massive sandstone, which appears to replace the coal at some places. A record secured south of the road forks in NW¼NE¼ Sec. 15 follows:

		Ft.	In.
Sandstone and covered	*Homewood*	41	0
Sandstone, ferruginous; and covered		8	0
Coal, blossom, *Bedford,* altitude 1,218 feet		1	2
Clay and covered		6	0
Sandstone, irregular, light-colored; and covered		25	0

In the southeastern corner of Richland Township, south and east of Wolf Creek, the higher land in Sec. 24 in the extreme southeastern corner of the township rises high enough to retain the Bedford horizon. It is known to be present from one or two poor exposures, but these are not clear enough to afford much evidence of the thickness or character of the coal.

ECONOMIC VALUE

The major area of Bedford coal which has been mined is a field in the adjacent portions of Salt Creek, Prairie, and Hardy townships. A second important area is below drainage in eastern Clark Township and extends eastward into Tuscarawas County. Another area is in southwestern Hardy Township and eastern Killbuck Township where the coal is more largely cannel. Elsewhere the bed has furnished small supplies of fuel in almost every township in the county from very local areas.

The Bedford coal ordinarily occurs in two benches separated by a thick shale parting, but additional partings are not uncommon. Care in mining is therefore necessary to produce a coal that does not contain too much ash. Where the Upper Mercer limestone and flint are present over the coal, roof conditions are good under heavy cover, but near the outcrop or under shallow cover the limestone may be separated into blocks by joint planes, commonly enlarged by solution and the cavities filled with clay. At the many localities where the limestone is absent the roof material is shale, generally of satisfactory strength. At only a few localities does the Bedford coal have a sandstone roof. The clay below the coal is ordinarily tough and siliceous.

The Bedford coal throughout most of the county is moderately hard, bright, banded bituminous coal, commonly containing thin bands of cannel coal. It is fairly high in volatile constituents and hence ignites readily and burns freely. Its heating value is moderate to good. The ash character is diversified because of lateral variations in the bed and depending on the amount of parting material removed or retained in mining. A sample of coal[1] taken in 1928 by W. S. Glock and L. O. Naffziger from the mine of C. E. Zehnder, in central Sec. 1, Prairie Township, shows the following structure and character (analysis by D. J. Demorest):

		Ft.	In.
Limestone.			
Coal, bony and shaly, roof		0	6
Coal, sampled	*Bedford*	0	2½
Coal, bony, rejected	*Bedford*	0	1
Coal, sampled	*Bedford*	0	2¾
Coal, bony, rejected	*Bedford*	0	1¾
Coal, sampled	*Bedford*	2	1
Shale, gray, floor.			

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, p. 27, 1929.

Proximate analysis	As received	Moisture free
Moisture	8.02	0.00
Volatile matter	40.97	44.54
Fixed carbon	44.93	48.85
Ash	6.08	6.61
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	67.58	73.47
Hydrogen	5.00	4.47
Oxygen	17.40	11.17
Nitrogen	1.41	1.53
Sulphur	2.53	2.75
Ash	6.08	6.61
	100.00	100.00

Air drying loss 3.62 per cent

		As received	Moisture free
Heating value	Calories	6,837	7,433
	B. t. u.	12,306	13,379
Fusion of ash	Incipient	2,116°F.	
	Complete	2,374°F.	

The Bedford coal in southern Hardy, eastern Killbuck, and northwestern Mechanic townships is in part or in whole cannel in character. Much of it is too shaly to be satisfactory for fuel purposes. Shaly cannel coal, 7 feet in thickness, was formerly mined at the "Leasure" (Shevilard) mine in southwestern Hardy Township, one-fourth mile north of the northwest corner of Sec. 4, Killbuck Township, and shipped to Mt. Vernon for coal oil extraction.

The clay below the Bedford coal is commonly thin, sandy, and impure. It may have some future value at those few localities where its thickness and quality are unusually favorable. At its best it is siliceous, plastic clay which might be used for making brick, hollow block, sewer pipe, or stoneware. At present the Bedford clay is used at only one locality in Ohio, at Dalton in Wayne County.[1]

UPPER MERCER LIMESTONE

STRATIGRAPHY AND EXTENT

The Upper Mercer member, the marine horizon overlying the Bedford coal, extends with some wants across Ohio from Columbiana and Mahoning counties on the north to Scioto and Lawrence counties in the southern part of the State.[2] In the northern part of Ohio the Upper Mercer member consists largely of limestone and flint, whereas in the southern part it contains less flint and limestone and passes into an iron ore.

In Holmes County the Upper Mercer marine member is due in all townships of the county but it is absent at many localities, its place

[1] Stout, W., and others, in Coal Formation Clays of Ohio: Geol. Survey Ohio Bull. 26, p. 195, 1923.

[2] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 142, 1927.

being taken by clay shale or siliceous shale. The average thickness of the member, calculated from all the exposures measured in Holmes County, is 1 foot 11½ inches. The greatest thickness of the Upper Mercer limestone seen in the county is 11 feet 4 inches, in the central part of Richland Township. At most outcrops the thickness is not more than 3 feet and at many it is less. The position of the Upper Mercer limestone is directly over the Bedford coal, locally lying directly upon it and at places with 1 or 2 inches of clay shale intervening. As the stratigraphic position of the Bedford coal, which is much more persistent in Holmes County than the overlying limestone, has been given in relation to the lower and upper beds, it is not necessary to give these figures again for the overlying limestone.

The material overlying the Upper Mercer marine horizon is nearly everywhere shale, tending immediately over the limestone to be a clay shale, at places containing small iron concretions and grading upward within a few feet to siliceous shale, and thence frequently to sandy shale. Locally a few feet of thin-bedded sandstone occurs above the Upper Mercer limestone and underneath the Tionesta coal horizon. In a small area in Richland Township the massive Homewood sandstone overlies the member or replaces it.

The Upper Mercer limestone is dark blue gray in color, somewhat darker than the underlying Lower Mercer limestone. It is generally fine in texture. The flint associated with the limestone is blue black, dense, with some gray or tan mottling not arranged in layers. The flinty portions may have a few very small cavities lined with tiny crystals of crystalline quartz which is commonly transparent. The flint is almost vitreous in luster very brittle, and has a conchoidal fracture. Sharp slivers and fragments result when a fresh piece of the flint is broken by a hammer. At a weathered outcrop where rectangular blocks of this flint have been broken loose by frost action, the material is an ossified-appearing, whitish-gray mass, which is cellular in structure due to the solution of the contained calcium carbonate. Such masses have the appearance of weathered bone and are very light in weight. Curiously, the flinty portion of the bed seems to weather more rapidly at outcrops than does the calcareous part of the bed, probably due to the more rapid weathering by freezing of water which has entered joints. At many outcrops the only evidence that the bed is flinty is scattered grayish, ossified-looking blocks of the calcareous portion of the bed which is still firm and in place, lying on the slopes below the outcrop.

The Upper Mercer member was deposited under marine conditions as is shown by the fossils of marine organisms, principally brachiopods. Fossils are contained in both the limestone and the flint portions of the bed, although the former tends to be more abundantly fossiliferous. Where calcareous shale overlies the Upper Mercer limestone it is generally extremely fossiliferous and offers good collecting. The member is not as fossiliferous as is the underlying Lower Mercer limestone or the overlying Putnam Hill limestone.

A careful study of the character and origin of the flint has been made by Stout,[1] especially in Muskingum County. He considers various hypotheses for the origin of the flint and concludes that it was formed as "original deposits laid down in shallow water under conditions similar to those where limestones were deposited, but siliceous material from organic life was present in considerable quantities, and was either deposited directly or was substituted for calcium carbonate of newly formed limestone."[2] The color of the black flint, which ranges from dark blue-black to coal black, is thought to be due to carbon and to iron oxide pigment. The quantity of coloring matter is probably small but due to colloidal dispersion of the pigment the maximum effect is exerted. The carbon probably is not as important as the iron oxide.[3]

Paint Township.—At most places in Paint Township the Upper Mercer limestone is wanting above the Bedford coal. Just west of the Holmes-Tuscarawas county line, 1 mile north of Indian Trail Creek, a few blocks of black fossiliferous flint overlie the Bedford coal but the Upper Mercer limestone and flint are not in place. The member was formerly exposed in NE¼ Sec. 33, where Conrey[4] measured 4 feet of dark-blue, fossiliferous limestone overlain by 2 feet of flint in the roof of a mine in Bedford coal. The base of the Upper Mercer member is 49 feet below the Putnam Hill limestone.

Salt Creek Township.—In Salt Creek Township the Upper Mercer limestone and black flint are generally present over the Bedford coal in the northern and northwestern parts of the township. No outcrops are present in the northeastern corner because of the covering of glacial drift. In the southwestern portion the Upper Mercer members may be absent from the stratigraphic section. In the northern part of the township, in NE¼ Sec. 3, one-quarter mile northwest of Guthrie School, the Upper Mercer member forms the roof of a mine in the Bedford coal. It is divided into two parts—a lower dark-blue, fossiliferous limestone 9 inches thick, overlain by 2 feet 6 inches of hard, irregularly fractured blocks of flinty, fossiliferous limestone containing discontinuous masses of more pure flint (11A-327).

In the western part of the township the Bedford coal is accompanied by Upper Mercer limestone. In SE¼NW¼ Sec. 6 the Bedford coal is overlain at an altitude of approximately 1,140 feet by 2 feet of dark, blue-black, fossiliferous flint (13-59).

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[1] Stout, W., Geology of Muskingum County: Geol. Survey Ohio Bull. 21, pp. 109-113, 1918.

[2] *Ibid.*, p. 113.

[3] *Ibid.*, p. 113.

[4] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, p. 106, 1921.

Prairie Township.—In Prairie Township the Upper Mercer limestone is present in the northeastern corner and the southeastern corner. It is absent because of erosion in the central and northwestern parts, and seems to be absent because of lack of deposition in the southwestern part. In the northeastern corner of Prairie Township, 3 feet of hard, dark-blue, fossiliferous, flinty Upper Mercer limestone forms the roof in an old mine of the Bedford coal in NE¼SW¼ Sec. 25, approximately 1,110 feet above sea level (16-54, Appendix).

In the central eastern part of Prairie Township in Sec. 1, where several mines exist in the Bedford coal, the roof is formed by the Upper Mercer limestone. Because it is close to the top of the hill small solution channels have formed at the bottom of the limestone and the rock is therefore called "honeycomb" rock by the miners. Some of these tiny caves are partially or wholly filled with clay. The structure and character of the Upper Mercer limestone and flint are shown by the following section measured at the mouth of an old mine in SE¼NW¼NE¼ Sec. 1:

		Ft.	In.
Soil, sand-derived		3	0
Flint, very fossiliferous, dark to tan, weathered	*Upper Mercer*	0	10
Limestone, weathered to clay	*Upper Mercer*	1	1
Flint, black, fossiliferous	*Upper Mercer*	3	3
Coal, weathered, *Bedford*		3	4
Clay shale, dark, soft.			

In the southeastern corner of Prairie Township, Upper Mercer limestone accompanies the Bedford coal at several outcrops north of Colliers Run. In W½ partial Sec. 13 the Upper Mercer limestone contains a great deal of very dark, hard flint (21-48). Near the township line, in the headwaters of Colliers Run, the flinty limestone is 3 feet in thickness (47-51).

Ripley Township.—In Ripley Township the Upper Mercer limestone is either absent or is concealed by glacial drift.

Knox Township.—In Knox Township the Upper Mercer limestone and flint are absent from the section at many places. In the central southern part of the township in S½ Sec. 23 scattered pieces of weathered, very fossiliferous, black, flinty Upper Mercer limestone, are present along a road at an elevation of approximately 1,260 feet. The Upper Mercer member is in place to the south in Richland Township. In the eastern part of Knox Township the member is 1 foot 3 inches thick in a ravine, 1⅛ miles west of Monroe Township and 1½ miles south of Ripley Township, east of the high knob more than 1,400 feet above sea level, 1½ miles south of Nashville (25-396).

Monroe Township.—The Upper Mercer member is generally wanting in Monroe Township, having been seen only in the western part of the township. In a ravine just south of a road 1 mile northeast of Bell Ridge School one-quarter mile east of the Knox-Monroe township line, in the central western part of the township, loose pieces of black flint were noted overlying the Bedford coal at an altitude of approximately 1,190 feet. The character and stratigraphic position of the bed are well shown in the deep ravine one-half mile east of the Knox Township line and 2¼ miles north of the Richland Township line, where the flinty limestone is 3 feet 9 inches in thickness above an abandoned mine in the Bedford coal (35-358A).

In the southwestern part of the township about 1 mile east of the Knox-Monroe township line and 1 mile north of the Richland-Monroe township line, loose blocks of weathered flint lie at an altitude of approximately 1,160 feet.

Hardy Township.—The Upper Mercer limestone is present only in the northeastern portion of Hardy Township. Elsewhere its place is taken by a siliceous or sandy shale. In NE¼SW¼ Sec. 4 several feet of Upper Mercer limestone lies immediately over the Bedford coal in the mine of H. J. Gindlesberger. Two feet of limestone is seen in the mine but the member is thicker than this. The member is dark blue, fossiliferous, and much-weathered at this location, with solution channels at the base of the bed. The partly flinty limestone contains flint which is not in continuous layers but in discontinuous masses distributed throughout the limestone. Here the member is perhaps on the whole less flinty than is most Upper Mercer limestone. The Upper Mercer overlies the Bedford coal in that part of Hardy Township north of Honey Run and east of Killbuck Creek. It is dark, partly flinty limestone, 3 feet thick, in N½ Sec. 5, and of about the same thickness west of Sec. 5. West of Killbuck Creek the limestone is replaced by shale.

Berlin Township.—The Upper Mercer limestone was not seen in Berlin Township, its place over the Bedford coal being taken by shale.

Walnut Creek Township.—The best representation of Upper Mercer limestone in any township in Holmes County is in Walnut Creek Township, but even here the bed is somewhat unsteady and is missing from a considerable part of the township. In general the bed is found in the central, the northwestern, and the southern parts and is absent from the northern and northeastern parts. In the northwestern part of the township the marine member overlies the Bedford coal at an altitude of approximately 1,085 feet (80-219, Appendix).

In the extreme southwestern corner of the township the marine member crops out immediately over the Bedford coal about 1,400 feet above sea level, where it is black, flinty limestone about 2 feet in thickness (84-137).

In the central part of Walnut Creek Township in the vicinity of the village of Walnut Creek and north across Goose Creek, the Upper

Mercer limestone and flint are well developed, cropping out prominently in ravines and along road banks. From west to east the altitude of the Upper Mercer marine member ranges from 1,050 feet in SW¼ Sec. 12 (86-120) to 1,030 feet in central Sec. 16, a distance of 2½ miles, where the member consists of one massive bed of hard, black, fossiliferous flint ranging in thickness from a little more than 2 feet to about 3 feet (89-132). The small proportion of limestone present is not arranged in a separated stratum but is intimately associated with the flint in larger or smaller masses. South of Walnut Creek in NW¼SE¼ Sec. 21, the Upper Mercer black, flinty limestone, 2 feet in thickness, overlies the Bedford coal at an altitude of 1,017 feet. In the extreme southeastern part of Walnut Creek Township, the place of the Upper Mercer marine member is taken by shale.

Clark Township.—The horizon of the Upper Mercer limestone is below drainage in most of Clark Township, but outcrops at this horizon are found near the bottoms of valleys in the northern and in the western part. Although the Bedford coal does not crop out in the northeastern corner of the township, it has been reached a short distance below the surface by a slope mine of the General Clay Products Company in NE¼ Sec. 7. Here no limestone overlies the Bedford coal but 2 inches of dark, carbonaceous shale contains marine fossils and this is in turn overlain by 4 feet of siliceous, gray shale containing a few small, ovoid, iron concretions. The carbonaceous and ferruginous shale was deposited under marine conditions and is correlative with the Upper Mercer limestone found elsewhere in the county.

In the central northern part of Clark Township the Upper Mercer marine member seems to be entirely a flint about 2 feet in thickness in SW¼SW¼ Sec. 2 (95-172, Appendix). In NW¼NE¼ Sec. 3 the Upper Mercer limestone is exposed at a road forks on the line between Walnut Creek and Clark townships at an altitude of 1,050 feet, where the member consists of 2 feet of hard, dark limestone, with much blue-black flint, separated from the underlying Bedford coal by 2 inches of clay (85-119).

In the northwestern corner of Clark Township the Upper Mercer limestone and flint crop out near the stream in the vicinity of Charm about 1,060 feet above sea level (103-88). South of Charm the interval between the Upper Mercer and Lower Mercer limestones decreases (104-90).

In the central western part of Clark Township the Upper Mercer marine member crops out at several places, overlying the Bedford coal at an altitude of about 1,040 feet. It consists almost entirely of hard, black, fossiliferous flint ranging in thickness from 1 to 2 feet (105-263). In the southwestern part of Clark Township the Upper Mercer limestone is absent, its place being taken by shale.

Mechanic Township.—In Mechanic Township the horizons of the Bedford coal and the overlying Upper Mercer limestone are widely distributed, but the Upper Mercer limestone is wanting almost entirely, its place being occupied by shale ranging from clay to siliceous in character. The Upper Mercer limestone is present in a small area in the western central part of Mechanic Township in the vicinity of Bucks Run one-fourth mile east of SE¼ Sec. 11, where 1 foot 6 inches of hard, black flint overlies the Bedford coal at an altitude of 1,010 feet (132-125, Appendix).

Killbuck Township.—Although the Bedford coal is almost everywhere present where due in Killbuck Township, the Upper Mercer limestone, which directly overlies the coal in much of Holmes County, is almost totally lacking in this township. In the northeastern part of the township Dr. Wilber Stout has reported[1] 4 feet 7 inches of Upper Mercer limestone separated from the underlying Bedford coal by 2 feet of shale in SE¼ Sec. 8.

In the southwestern part of the township, in NW¼SE¼ Sec. 23, in a gully just north of the road, the Bedford coal is overlain by 8 inches of very dark blue, granular, hard, fossiliferous Upper Mercer limestone. The member is 42 feet below the Putnam Hill limestone and 24 feet above the Lower Mercer limestone (144-345A).

Richland Township.—The Upper Mercer limestone crops out in a fairly prominent way in the central part of Richland Township from the northern border to the southern boundary. Its place is taken by shale in the eastern and western parts of Richland Township. The member is exposed prominently in secs. 3 and 4 in the northern part of the township and contains much more limestone and less flint than is the usual case, approaching the Lower Mercer in appearance (159-360). In NW¼NE¼ Sec. 4 the marine member is poorly exposed along a road at an altitude of about 1,275 feet (161-380).

In the central part of the township south of the Pennsylvania Railroad, the greatest thickness of the Upper Mercer member seen in Holmes County lies at an elevation of 1,220 feet near the top of the ridge in NW¼NE¼ Sec. 13 where a lane enters the highway. The member here consists of two portions, an upper calcareous, very fossiliferous shale 3 feet 2 inches in thickness and a lower somewhat flinty limestone 8 feet in thickness (163-362). Loose blocks of black flint are present near this outcrop but they could not be found in place. In NE¼SW¼ Sec. 13, 1 foot 6 inches of dark blue, fossiliferous limestone, resembling in appearance the Lower Mercer limestone, overlies the Bedford coal at an altitude of about 1,225 feet. The interval between the Upper Mercer limestone and the Brookville coal is here 24 feet 4 inches (164-364). The calcareous shale found over the limestone part of the member in the northeastern part of this section is absent. Scattered blocks of black flint were noted near

[1] Personal communication.

the outcrop but were not seen in place. Evidently in this part of the township the flint occupies the lower part of the member and because it weathers more rapidly than the limestone, outcrops are more readily obscured than those of the less flinty limestone upper portion of the bed.

To the south and southeast, in secs. 18 and 19, black, flinty limestone overlies the Bedford coal but outcrops are very obscure (166-373). In SW¼SW¼ Sec. 22, along the road at the Coshocton County line, 10 inches of hard, black, shiny flint overlies the Bedford coal at the altitude of about 1,210 feet (168-374).

ECONOMIC VALUE

The Upper Mercer member is of very little value as a limestone for lime or ground-limestone production. A few pieces have been included with the Lower Mercer or the Putnam Hill limestones in the burning of local kilns for agricultural lime, but the siliceous character of the rock is such that unsatisfactory results were evident.

The aborigines used the Upper Mercer black flint for weapons and tools, deriving their raw material from Bedford Township, Coshocton County,[1] but there is no evidence that material from Holmes County was so used. The member at the Coshocton County locality reaches a thickness of more than 10 feet at some outcrops.

The Upper Mercer flint does not occur as pebbles suitable for use as grinding pebbles,[2] and it is probable that the fractured character of the flint would preclude its fabrication for this purpose. On the other hand, the fracturing of the flint would make its quarrying and grinding easier if ground flint for sandblasting were sought.

TIONESTA COAL AND CLAY

STRATIGRAPHY AND EXTENT

The Tionesta (or 3-B) coal and clay are of limited development in Ohio, the most important areas being in Muskingum and Tuscarawas counties.[3] In Holmes County these members are remarkably persistent, generally being found midway between the Bedford coal (which is at some places overlain by the Upper Mercer black flint) and the Brookville coal (which is overlain by the Putnam Hill limestone). The Tionesta members crop out in every township of the county.

The average thickness of the coal is 4½ inches, the maximum being 3 feet 6 inches, the thinnest, a mere soot streak. The clay is from 2 to 4 feet thick. The coal is generally but 2 or 3 inches, and at many places is

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[1] Meyers, T. R., Geology of Jefferson and Bedford Townships, Coshocton County, Ohio, Unpublished thesis, The Ohio State University, pp. 53-54, 1929.

[2] Eardley-Wilmot, V. L., Abrasives, in Industrial Minerals and Rocks: A. I. M. E., New York, p. 51, 1937.

[3] Stout, Wilber, Geology of Vinton County: Geol. Survey Ohio, Bull. 31, p. 151, 1927 *Ibid.* Geology of Muskingum County: Geol. Survey Ohio, Bull. 21, p. 115, 1918.

only a thin line of carbonaceous material on the outcrop. The remarkable feature of this coal is its persistency — it can almost everywhere be found where due, being replaced by Homewood sandstone within only a few small areas.

The Tionesta coal lies, on the average, 26 feet 11 inches below the Putnam Hill limestone and 28 feet 9 inches above the Bedford coal. Locally the Tionesta members are much closer to the Putnam Hill limestone and at a few localities the interval is so small that the Tionesta and Brookville clays make up a single bed, separated only by an inch or two of Tionesta coal.

The members under discussion are commonly overlain by shale, which is everywhere siliceous and at some localities sandy. At a few outcrops the material above is thin-bedded, shaly sandstone. In this county there is very restricted development of the massive Tionesta or Homewood sandstone that is commonly found overlying and locally replacing the Tionesta coal and clay in other parts of Ohio.

The material below the Tionesta clay is at many exposures white, clay-bonded sandstone. However, such a sandstone is not so universally found beneath the Tionesta as beneath the Brookville clay. Most of the interval between the Tionesta clay and the Upper Mercer limestone is sandy shale.

The Tionesta clay is very siliceous, and the lower portion is generally sandy and micaceous. It will not be of much ceramic importance except in those few areas where it lies so close to the Brookville clay that the two beds can be mined together.

Paint and Salt Creek Townships, Wayne County.—Less than 2 miles north of Holmes County, the Tionesta coal has been mined in NE¼NE¼ Sec. 13, Salt Creek Township, Wayne County, and 2 feet 8 inches of coal is reported from S Sec. 14.[1] This lens of Tionesta coal continues to the east into NW¼ Sec. 18, Paint Township, where the coal was mined by stripping in 1945 by the Blue Crystal Mine, Inc. The coal bed is irregular in altitude, being thrown into gentle folds (called "rolls" by the miners), the structural relief being 10 feet or more over a distance of 100 yards. The coal is overlain by sandstone in one part of the pit and by sandy shale in another. In a few places glacial drift rests directly upon the coal, and in some such occurrences the upper part of the coal bed has been removed by glacial erosion. A section measured at the east end of the pit is as follows:

	Ft.	In.
Glacial drift; till, pebbly to cobbly, with silty matrix; ranges in thickness from 0 to 20 feet	12	0
Sandstone, coarse; preglacially weathered to 1- to 2-inch beds and into brick-like blocks	8	0

[1] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24 p. 110, 1921.

		Ft.	In.
Coal, bright, fine-banded, with ¼-inch anthraxylous layers	*Tionesta,* altitude 1,190 feet	2	5
Shale, carbonaceous, dark gray to black		0	3
Coal, bright, blocky, anthraxylous		2	4
Sandstone, white, clay-bonded		2	0

It is not known if this lens of Tionesta coal extends southward under cover into Salt Creek and Paint Township of Holmes County.

Paint and Salt Creek Townships, Holmes County.—Outcrops at the Tionesta horizon are not common in northern Holmes County because of the drift covering, but at those exposures seen, the Tionesta coal is only a few inches in thickness, underlain by 2 or 3 feet of siliceous clay. The members lie about midway between the Brookville coal and the Upper Mercer limestone. It is possible that lenses of thicker Tionesta coal may be present but unobserved, similar to the deposit just north of the county.

Prairie Township.—According to Wright,[1] sometime before 1884 Tionesta coal was mined from "near the north line of Prairie Township" for shipment by rail from Fredericksburg. The coal "was 3½ to 4½ feet thick over a limited area, which is mined out. Around the margin, 32 inches of good coal remain. . . . The coal is a cementing, purple ash coal, contains much sulphur, and is apt to attach to grate bars." The section measured at Wayne Hill, Prairie Township, by Wright is as follows:

	Ft.	In.
"Massive yellow sandstone (Hecla)	35	0
Brookville (?) coal 4 in. and clay 6 in.	0	10
Massive sandstone, clay shale below	20	0
Tionesta coal (No. 3b)	3	0
Clay	5	0
Shales	22	0
Upper Mercer limestone, blue	5	0
Upper Mercer [*Bedford*] coal (No. 3a) "limestone" vein	3½	0
Clay	2	0
Shale	19½	0
Lower Mercer limestone, blue	3	0
Lower Mercer, [*Middle Mercer*] coal (No. 3)	2	0
Clay	3	0
Coal measures, concealed, about	80	0
Waverly sandstone and shales, about	75	0
Railroad, 1½ mile south of Fredericksburg."		

At all outcrops seen in Prairie Township in the present investigation the Tionesta coal is only a few inches in thickness. The presence of undiscovered lenses of thicker coal is possible, but not regarded as very probable.

[1] Wright, A. A., Report of the Geological Survey of Ohio, Vol. V, pp. 827-828, 1884.

Ripley Township.—In Ripley Township, because of the thick glacial deposits, the Tionesta members are poorly exposed. In a road ditch in central Sec. 8, in the southwestern part of the township, the Tionesta coal is 10 inches in thickness (22-357, Appendix).

In Knox Township, there is no evidence of any significant development of Tionesta coal or clay.

Monroe Township.—In Monroe Township, with the exception of one small area, the Tionesta coal is very thin and the underlying clay generally sandy, as illustrated by the following section measured along the road five-eighths mile east-northeast of Welcome:

	Ft.	In.
Limestone, loose blocks, *Putnam Hill*		
Clay and covered, *Brookville*	6	0
Shale, siliceous	10	4
Clay, light gray	1	0
Coal, shaly, *Tionesta*, altitude 1,180 feet	0	5
Clay, dark gray, carbonaceous	0	4
Clay, sandy, micaceous	2	4
Shale, siliceous to sandy	20	0

However, the ridge in southeastern Monroe Township, extending into Killbuck Township, east of Philips School, contains Tionesta coal of considerable thickness. Three-fourths mile northeast of Philips School and 1¼ miles northeast of Welcome, Tionesta coal 2 feet 9 inches thick was dug out in a road ditch, at an elevation of 1,180 feet. The coal is weathered but appears to be only fair in quality.

Hardy Township.—In Hardy Township the Tionesta members are closer to the Putnam Hill limestone in the northeastern and southeastern parts of the township than is the usual case. In the southeastern part, in NW¼SE¼ Sec. 17, five feet of Tionesta clay lies directly under 10 feet 9 inches of Brookville clay, with only 3 inches of Tionesta coal between them (61-24, Appendix).

The members under discussion are generally present but show no unusual features in Berlin Township.

Walnut Creek Township.—The Tionesta members in Walnut Creek Township are almost everywhere present where due. In the vicinity of Walnut Creek village the clay is thinner and more sandy than usual. In SW¼NW¼ Sec. 16 Tionesta coal, 1 foot 1 inch thick, underlain by 1 foot 6 inches of plastic clay, crops out at an altitude of approximately 1,055 feet (89-132).

Clark Township.—In Clark Township the Tionesta coal is very thin, being generally 2 to 3 inches thick or less. The clay, commonly somewhat sandy, at most places is from 2 to 5 feet thick. At the five corners one-half mile southwest of Farmerstown a poor outcrop indicates that the Tionesta clay here may be as much as 10 feet thick. South of Clark Township, in Crawford Township of Coshocton County, the Tionesta coal and clay are present in the same stratigraphic positions as in Holmes County, and exhibit the same character.

Mechanic Township.—The thin Tionesta coal and clay are close to the underlying Bedford coal in the northeastern part of Mechanic Township (124-81, Appendix). In the northwestern part of the township the Tionesta coal has a thickness of 2 or 3 inches. The underlying clay is thin and sandy.

Killbuck Township.—The greatest thickness of Tionesta coal seen in Holmes County is in the central northern part of Killbuck Township at the south end of the ridge lying mainly in southeastern Monroe Township, where also are indications of thick coal at this horizon. The coal has been mined by G. C. Quillen from an opening just south of the township line, 1½ miles north of Killbuck, in NW¼NE¼NE¼ Sec. 1, but it was not possible to enter the mine when visited. Along the road ditch east of the mine mouth the coal is 3 feet 6 inches in thickness and the underlying clay is 6 feet (142-285).

One mile east, along a road in SW¼NE¼ Sec. 5, the coal is 3 inches thick, but the underlying clay is 7 feet 8 inches thick (141-288). The clay at this locality is of fair quality, being light in color and moderately siliceous.

In the southwestern corner of Killbuck Township and the southeastern corner of Richland Township the massive Homewood sandstone replaces the Tionesta members, as it does also in central eastern Richland Township and in a part of Monroe Township, Coshocton County.

ECONOMIC VALUE

The Tionesta coal is not one of the important coal beds of Ohio, but is mined for local use in several counties. In Holmes County the bed was mined in Prairie Township more than 60 years ago. The body of minable coal was small and soon exhausted. The Tionesta coal has been mined in Killbuck Township, as already described, where the minable body of coal is not of large size but probably extends into southeastern Monroe Township. It is possible that small lenses of coal may be present but concealed by glacial drift in northern Holmes County but if present these are probably small and therefore could not support large mining operations.

The Tionesta coal is variable in quality. The ash content is rather high and the heating value only moderate. The Tionesta coal from Wayne County is unusually bright, of moderate ash content if the partings are excluded, and has found acceptance for domestic and steam purposes.

The Tionesta clay is an important bed for ceramic purposes in many Ohio counties. It has been used extensively in Perry, Muskingum, and Stark counties[1] for a wide variety of products. In Holmes County the

[1] Stout, W. and others, Coal Formation Clays of Ohio: Geol. Survey Ohio Bull. 26, p. 196, 1923.

bed has not been mined. Its thickness generally ranges from 2 to 4 feet, although locally it is thicker. In this county it has not the thickness nor quality of the Brookville or Lower Kittanning clays, but in selected areas Tionesta clay may have some value in the future. It should be fitted for making sewer pipe, buff face brick, stoneware, and similar products, although no tests are available on Tionesta clay from Holmes County. Probably shale should be added for color in sewer pipe manufacture. Because the bed is variable in thickness, careful determination of volume available for a proposed operation should be made, as changes in thickness over short distance may be expected.

HOMEWOOD SANDSTONE

The Homewood or Tionesta sandstone is very poorly developed in Holmes County. This sandstone member, where present in Ohio, lies between the Tionesta coal and the Brookville coal, but it replaces these members at many places. Throughout almost all of Holmes County only thin, sandy beds occur in association with the shale which normally occupies the Tionesta-Brookville interval. However, in a very few localities in the county, coarse sandstone occurs at this horizon.

In a restricted area in NE¼ Sec. 18, Killbuck Township, and NW¼ Sec. 19, Mechanic Township, 45 feet of sandstone, which is in part massive, underlies the Brookville members and replaces the Tionesta beds (153-76, Appendix).

A local development of the Homewood sandstone occurs in southwestern Ripley Township and the lens extends a short distance across the township line into Monroe and Knox townships, where it is visible along the state road one-half to 2 miles east of Nashville. At this place a higher sandstone, the normal place of which is above the Lower Kittanning coal, appears to coalesce with the Homewood, providing a very thick sandstone sequence.

In central eastern and southeastern Richland Township, and in southwestern Killbuck Township, massive sandstone is present below the Putnam Hill limestone and Brookville members. In NE¼ Sec. 15 in eastern Richland Township, approximately 50 feet of sandstone lies over the Bedford coal, replacing the Tionesta coal horizon. The top of this sandstone appears to rise higher stratigraphically to the west and to occupy the Putnam Hill horizon.

The most prominent outcrops of the Homewood sandstone are ledges and cliffs in fields and along the road near the more easterly road fork in SW¼ Sec. 23, Killbuck Township, where the sandstone is at least 30 feet in thickness. To the south, in Monroe Township, Coshocton County, the Homewood sandstone is even better developed, replacing the Brookville members above, and extending downward almost to the Lower Mercer limestone. In pioneer days the stone in this locality was quarried for house foundations, but the small area and irregularity of the Homewood member in Holmes County make it unlikely that present-day quarrying on a commercial scale could be supported, especially in competition with the widespread and favorably-known Massillon sandstone.

BROOKVILLE CLAY

STRATIGRAPHY AND EXTENT

The Brookville clay is the uppermost member of the Pottsville formation. It is probably the most important clay stratum in Holmes County and is widely distributed throughout the whole area. It is this clay which has been used for ceramic manufacture. The Brookville is present where due in every township, except Washington, except for a very few localities where the clay and the overlying Brookville coal and Putnam Hill limestone have been replaced by coarse sandstone. As its top is the top of the Pottsville formation, the position of the clay is shown in detail on the geologic map of Holmes County which accompanies this report.

The average thickness of the Brookville clay, determined from 45 measurements throughout the county, is 6 feet 5 inches. The clay exceeds this average thickness at many exposures, a thickness of 8 or 10 feet being not at all uncommon, and at one exposure the clay is 14 feet 4 inches in thickness. The clay lies immediately beneath the Brookville coal, which in turn is overlain by the Putnam Hill limestone. At some localities the clay rests immediately upon the underlying thin Tionesta coal and its thicker associated clay so that the two beds appear to be a single one. Elsewhere sandy shale or white, shaly sandstone intervenes between the bottom of the Brookville clay and the Tionesta coal. Typically the Brookville clay rests upon white, thin-bedded, micaceous, clay-bonded sandstone. Sometimes the dividing line between the underlying white sandstone is very clear whereas at other places the clay grades into the underlying sandstone. The average interval between the base of the Brookville clay and that of the underlying Tionesta coal is 19 feet 1 inch.

Throughout the county the Brookville clay is plastic and from fair to good in quality. It is generally light gray in color, weathering to white. Most of it is somewhat siliceous. The bottom portion of the bed is more siliceous than the upper and at some places the bottom 2 or 3 feet is sandy and contains muscovite flakes.

Paint Township.—Brookville clay of good thickness and fair quality is present beneath the Brookville coal in Paint Township: A large part of the township is underlain by the Brookville members but at most places the outcrop is obscured by glacial drift. Several outcrops are known in the northern part of the township and others in the southern part along the north side of the valley of Indian Trail Creek. The clay in this township reaches a maximum observed thickness of 8 feet in NW¼NW¼ Sec. 27 (3-232). The clay is light gray, plastic, tending to be siliceous, and grades downward to sandy clay and thence to white, clay-bonded, micaceous sandstone. Clay of similar thickness and quality probably underlies the ridge which extends from the northwest to the southeast corners of Sec. 27. At the end of this ridge in SW¼ Sec. 26, Brookville clay having a thickness of 7 feet 6 inches crops out at an elevation of approximately 1,190 feet (2-229).

In the southern part of Paint Township, north of Indian Trail Creek, the Brookville clay is from 4 to 6 feet in thickness and is light, plastic, and siliceous.

Salt Creek Township.—The northern and eastern parts of Salt Creek Township are high enough to retain the horizon of the Brookville coal and clay. In the eastern part of the township the covering of glacial drift is so thick that outcrops of the bedrock are uncommon and very little is known of the character of the Brookville members.

In the northwestern part of Salt Creek Township the Brookville clay is from 3 to 4 feet in thickness, light in color, plastic, somewhat siliceous, and of good quality. It crops out at an elevation of from 1,200 feet to 1,220 feet in sections 31, 32, 33, 5, and 6. Along the north-south road between NW¼SW¼ Sec. 5 and NE¼SE¼ Sec. 6 at a road fork, the overlying Brookville coal has been stripped in a small way and the underlying Brookville clay is exposed. Here the clay is 4 feet in thickness, white in color, and of good quality. A considerable area of the clay and coal is present on either side of the section-line road in secs. 5 and 6, with very little overburden so that the coal and the clay might be stripped together.

In the extreme southwestern corner of Salt Creek Township a small area is underlain by the Brookville members at an altitude of approximately 1,180 feet. The clay is of good quality, light in color, and has an average thickness of about 4 feet. In the central southern part of the township the hill 1 mile south of Fryburg, just north of the Salt Creek-Berlin township line, is underlain by 2 feet of Brookville coal and 5 feet of light, plastic Brookville clay of good quality.

Prairie Township.—Only a small area in the northeastern part of Prairie Township is underlain by the Brookville members. This area is confined to secs. 25 and 26, but its clay is of importance and has been used for ceramic purposes by the Mt. Cherry Coal and Clay Company. More clay has been used from just north of the county line in Wayne County, being burned at a plant which was located in Holmes County. In Sec. 25 the clay is exposed at an altitude of approximately 1,150 feet, being overlain by a minable thickness of Brookville coal, and at two mines the coal and clay have been taken out together. The mine roof is Putnam Hill limestone. The clay ranges in thickness from 5 to 6 feet and is light gray, plastic, and moderately siliceous. An analysis of the clay is given under "Economic Value."

A very small area in the central southern part of Prairie Township, in Sec. 16, is underlain by the Brookville members but no good exposures were found where the thickness of the clay could be measured. However, it seems to be several feet in thickness and to be of fair quality.

Ripley Township.—In Ripley Township the Brookville members are due only in the central portion and in the southwestern part. In the central part outcrops are very scarce because of the thick covering of glacial drift. The Brookville members in the southwestern part of the township are largely replaced by sandstone. A poor exposure of a coal smut and a clay blossom overlying 15 feet of white, thin-bedded, clay-bonded sandstone is present in a road ditch at the top of the ridge just above 1,280 feet in altitude in central Sec. 8 (22-357).

Knox Township.—The Brookville clay, accompanied by the overlying coal, is due near the top of the east-west ridge in the north central portion of Knox Township and along Bell Ridge in the eastern part. In general, the Brookville clay in Knox Township seems to be thin and unimportant except in that part of Bell Ridge near Bell Ridge School. One-quarter mile north of Bell Ridge School, 4 feet of light, plastic, moderately siliceous clay, exposed at an altitude of approximately 1,280 feet, is identified as Brookville. To the southwest, three-fourths mile southwest of Bell Ridge School, Brookville clay crops out along a road. The rock section is not clear enough for measurement, but the clay seems to be of fair quality and several feet thick.

Monroe Township.—In Monroe Township the Brookville coal and clay are well above drainage. In the northern part of the township outcrops of the bedrock are obscured by glacial drift and in the western portion the Brookville members seem to be replaced by sandstone. In general, where the Brookville clay is present in the township, it tends to be thicker than average and at some places the overlying Brookville coal is also of more than average thickness.

A small area of the Brookville clay of above-average thickness remains uneroded in the northeastern part of Monroe Township one-half mile west of the Monroe-Hardy township line and 1 mile south of the Prairie township line, just east of a crossroad whose elevation is 1,160 feet. The clay here is of good quality, becoming increasingly siliceous toward the bottom of the bed. Data secured along a road are as follows:

	Ft.	In.
Limestone, loose pieces, *Putnam Hill*, altitude, 1,190 feet	1	0
Coal blossom, *Brookville*	0	10
Clay, white to light gray, siliceous	14	4
Covered	5	0
Shale, siliceous	6	0
Coal blossom, *Tionesta*	0	4
Clay, light gray, plastic	3	0

To the south and southwest the Brookville clay thins rapidly and in that part of the township immediately south of the state road and north of Welcome the clay is not more than 3 or 4 feet thick. In the vicinity of Philips School, east of Welcome, the clay is 5 to 6 feet thick. Near the hilltops in the central southern part of the township southwest of Shrimplin Creek, the Brookville clay crops out prominently underneath the Putnam Hill limestone at an altitude of approximately 1,195 feet. An especially prominent outcrop of 9 feet 6 inches of Brookville clay is present at the 1,190-foot crossroad, 1 mile southwest of Welcome and five-eighths mile north of the Monroe-Killbuck township line (37-255, Appendix).

Hardy Township.—The Brookville clay is everywhere present where due in Hardy Township underlying the Brookville coal and the Putnam Hill limestone. It is found only near the tops of the hills in the vicinity of Killbuck Creek but farther from this stream it is overlain by several higher members. The quality and thickness of the clay in the township have a rather wide range. In the northeastern part of Hardy Township the Brookville clay is generally about 3 feet in thickness and is very siliceous. At the 1,128-foot road fork 2 miles northeast of Millersburg on the Benton road it is interesting to note that the Brookville clay is separated from the underlying Tionesta clay by only the thin Tionesta coal. Ordinarily the Tionesta coal and clay horizon is found many more feet than this below the Brookville clay. A section of the rocks measured here follows:

	Ft.	In.
Limestone, gray, dense, fossiliferous, *Putnam Hill,* altitude 1,129 feet	12	0
Coal blossom, *Brookville*	1	0
Clay, plastic, siliceous	4	4
Coal, very shaly, *Tionesta*	0	3
Clay, light, sandy	2	9
Shale, sandy	11	0

At the north corporation line of Millersburg, along the Benton road, 5 feet 6 inches of plastic, siliceous Brookville clay lying at an altitude of 1,140 feet is underlain by 10 feet 6 inches of white, clay-bonded sandstone. The presence of a white, clay-bonded, micaceous sandstone underneath the Brookville clay is common, but this is an unusual thickness of this type of rock.

Only the higher hilltops of the northwestern part of Hardy Township retain the Brookville members. The higher parts of the ridge in the vicinity of Gambles School show outcrops of the Brookville clay along the road at an altitude of approximately 1,170 feet. One-quarter mile south of Gambles School the Brookville clay is about 10 feet in thickness and the upper 6 or 8 feet is of good quality plastic clay, the lower part being siliceous (51-242). One-quarter north of Gambles School, 6 feet 5 inches of light, plastic, siliceous clay is present underneath the

Brookville coal and the Putnam Hill limestone (50-243). Several acres of clay is present in these two areas and the clay could be easily removed.

In the southwestern part of the township a considerable amount of Brookville clay lies near the tops of the ridges. The clay is 7 feet in thickness near the top of the ridge between Bear Run and Uhl Run, 1 mile east of Monroe Township (52-276). Its altitude rises from 1,165 feet at the eastern end of this ridge to 1,185 feet at the Hardy-Monroe township line. The clay underlying the ridge between Uhl Run and Hardy Run is thinner and more impure (55-401).

In southeastern Hardy Township the Brookville clay is of good thickness and of fair quality. In SE¼ SE¼ Sec. 11 and SW¼ SW¼ Sec. 15, one mile east of Millersburg, 7 feet of Brookville clay is underlain by 5 feet of white, clay-bonded sandstone at an altitude of approximately 1,100 feet. In Sec. 20 the clay has about the same thickness. The Brookville clay crops out at an altitude of 1,145 feet along the Millersburg-Berlin road in SE¼ SE¼ Sec. 14, where it is 7 feet 6 inches thick and is underlain by white, clay-bonded sandstone (60-66). In NW¼ SE¼ Sec. 17, between Sand Run and Upper Sand Run, the Brookville clay is 10 feet 9 inches thick and is separated from the underlying 5-foot-thick Tionesta clay by only a few inches of Tionesta coal (61-24).

Berlin Township.—The Brookville members are widely distributed in Berlin Township except in the central northern part where they have been removed by erosion. Their outcrop is concealed beneath the drift in the northeastern part of the township. In the southwestern part the Brookville clay at most outcrops consists of about 3 feet of light, plastic clay underlain by 3 feet or more of very sandy material and some micaceous material which grades downward into white, micaceous, clay-bonded sandstone.

The hill upon which the village of Berlin is situated is underlain by the Brookville members. To the west and south of the village the Brookville clay is 2 or 3 feet in thickness, being underlain by the usual ganister-like sandstone. Along the road one-half mile north of Berlin, however, in SW¼ SW¼ Sec. 6, the Brookville clay, which crops out at an altitude of approximately 1,140 feet along the road, has a thickness of 8 feet. The lower portion of the bed is very sandy (66-91).

In the southeastern part of Berlin Township the clay stratum under discussion is only of moderate thickness. The following section measured along the road one-fourth mile south of the Berlin-Sugar Creek road and one-fourth mile west of the Berlin-Walnut Creek township line is about typical of the bed in this part of the township:

	Ft.	In.
Clay shale, weathered	15	0
Limestone, gray blue, hard, platy, *Putnam Hill*	1	5
Coal, weathered, *Brookville,* altitude 1,150 feet	0	9
Clay, plastic, light	4	0
Sandstone, clay-bonded.		

Walnut Creek Township.—The Brookville clay is widely distributed in Walnut Creek Township, being above drainage throughout most of the area. In this township the Brookville clay is not as thick as it is in some other parts of Holmes County, but it is everywhere present where due, underlying the Brookville coal, which in turn underlies the Putnam Hill limestone. In the northern part of Walnut Creek Township the Brookville members are well exposed in many road cuts and in some ravines. A section which shows the typical character of the Brookville clay and its relationship to the overlying beds in the central northern part of the township was measured as follows just north of the cross-road 1 mile south of Trail:

		Ft.	In.
Bench mark, 1,156 feet.			
Clay shale, with ore balls		17	0
Ore, irregular, fossiliferous		1	0
Limestone, gray, dense, platy, fossiliferous, *Putnam Hill*		1	5
Clay shale, gray		0	3
Coal, shaly	*Brookville*	0	3
Clay shale, dark gray	*Brookville*	0	2
Coal, fair	*Brookville*	0	8
Clay, light, plastic, siliceous		4	0

In the central part of Walnut Creek Township, the bed crops out at an elevation of approximately 1,100 feet, the thickness ranging from 3 to 4 feet. In this part of the township the clay is very siliceous at the bottom. In the southwestern part of Walnut Creek Township, 3 feet of light, plastic, siliceous clay lies at an altitude of 1,100 feet along the road in the northeastern part of Sec. 23. Along the road in the extreme southwestern corner of the township, one-fourth mile east of the Walnut Creek-Berlin township line and three-eighths mile north of the Walnut Creek-Clark township line, 5 feet of Brookville clay underlies the thin Brookville coal and the Putnam Hill limestone (84-137, Appendix). The Brookville clay underlying the ridge upon which the village of Walnut Creek is situated ranges in thickness from 5 feet 6 inches in Sec. 12 to 4 feet, 2 miles east in Sec. 16 at the end of the ridge. At this latter locality the clay is underlain by 6 feet of white, clay-bonded, micaceous sandstone. Southeast of the valley of Walnut Creek in a road bank in NW¼SE¼ Sec. 25 the Brookville clay is 6 feet in thickness (93-134).

Clark Township.—In Clark Township the Brookville members are everywhere present where due, cropping out near the valley bottoms in the Sugar Creek drainage which includes most of the township but cropping out higher up on the valley walls in the western and northwestern parts of the township where the streams tributary to Doughty and Mill creeks have trenched lower than Sugar Creek and where the normal rise of the rocks to the west has also raised the members to a higher topographical level. Throughout most of Clark Township the Brookville clay has good thickness and is at least fair in quality.

In the northeastern part of the township the Brookville clay presents no unusual features, the following section measured along the state road in SE¼ NW¼ Sec. 14 being characteristic of the beds in this part of the township:

	Ft.	In.
Clay and covered, *Lower Kittanning*	8	0
Shale, sandy; a few thin streaks of ore, nodular	34	4
Clay, weathered, *Putnam Hill* horizon	3	0
Coal blossom, *Brookville*, altitude 1,040 feet	0	8
Clay, light, plastic, siliceous	6	0
Shale, light, sandy	10	0

In the central northern part of the township the clay is easily found where it crops out underneath the prominent Putnam Hill limestone. One-quarter mile southwest of Farmerstown the clay is exposed at an altitude of approximately 1,065 feet along the road in NE¼ Sec. 12, where it is 6 feet 9 inches thick (97-168, Appendix). Three-quarters of a mile southeast of Farmerstown in NE¼ SW¼ Sec. 11, the clay has a thickness of 4 feet 6 inches (96-164).

In the northwestern part of Clark Township the Brookville clay is from 6 to 8 feet in thickness but the lower half of the bed is sandy and mica flakes are discernible (101-118). In the southwestern part of the township the clay is present where due and shows no unusual features, except perhaps it is a little thinner than average. In the southern part of the township the Brookville clay ranges in thickness from 4 to 6 feet. It grades downward into white, micaceous sandstone. An unusual thickness—20 feet—of the white sandstone underlying the clay is shown along the road in SE¼ SW¼ Sec. 17 in the southeastern part of the township (114-149).

Mechanic Township.— In Mechanic Township the Brookville clay is always found where due, underlying the Brookville coal and the Putnam Hill limestone. The member is found near the tops of the hills in all parts of the township except the central and southern portions, which have been reduced by erosion below this stratigraphic horizon. The character and thickness of the clay as shown in the following section are about typical of that in the northeastern portion of Mechanic Township, where these data were secured along the road in NW¼SW¼ Sec. 1, five-eighths mile west of Doughty Creek:

	Ft.	In.
Clay shale, with iron concretions	30	0
Limestone, *Putnam Hill*, altitude 1,140 feet	1	0
Coal, *Brookville*	0	10
Clay, light gray, plastic, good	6	0

In the central northern part of the township the clay under discussion is from 5 to 7 feet thick and is light in color and plastic in kind. It is underlain by clay-bonded, white sandstone. In the northwestern part of the township the clay has good thickness, attaining 10 feet in NW¼ NE¼ Sec. 1 (133-36).

Where exposed in the southwestern portion of the township, the Brookville clay presents no departure from the usual characteristics and in general it is not thicker than 6 feet. This member is absent because of erosion in the central and central southern parts of the township. In the southeastern part, the Brookville clay and associated beds are present only at the tops of the highest hills and the members show no unusual features.

Killbuck Township.—In Killbuck Township, the Brookville clay and associated beds remain uneroded in only a small area in the northeastern part of the township in secs. 4 and 5, in a larger area in the central eastern part of the township, and near the top of scattered hills in the southeastern part and the southwestern part. The small area of Brookville clay remaining uneroded in the northeastern part of Killbuck Township, north of Killbuck Creek, is similar to the larger body of this member in the southwestern part of Hardy Township immediately to the north, which has already been described.

An unusual thickness of the Brookville clay is recorded from two small areas in the southwestern part of the township. The top of the knob in NW¼ NE¼ Sec. 22 is underlain by Brookville clay at an altitude of 1,180 feet, which is 11 feet 8 inches thick (145-368, Appendix). The lower part of the clay is micaceous and sandy. One mile and a half southwest a larger area in S and SW Sec. 23 which extends to the south into Coshocton County is underlain by Brookville clay. The character and thickness of the clay where it is exposed along the road just east of the road fork in SE¼ SW¼ Sec. 23 are as follows:

	Ft.	In.
Clay shale, with small ore balls	3	0
Limestone, gray, hard, somewhat granular, fossiliferous; not full thickness, *Putnam Hill*, altitude 1,205 feet	1	6
Covered	1	0
Clay, light, plastic, siliceous; (thickness increased by slumping?)	11	2
Ore, weathered	1	6

The Brookville clay present underneath the Putnam Hill limestone in the central eastern part of Killbuck Township in secs. 13 and 14 ranges from 4 to 6 feet in thickness and is of average quality. The small areas of clay remaining uneroded in secs. 18 and 23 in the southeastern part of the township are of less than average thickness and are very sandy.

Richland Township.—The areas of Brookville clay remaining uneroded in Richland Township are small and unimportant and are confined to the central and southern portions of the township. Outcrops are found near the tops of several knolls which rise above the general level of French Ridge, from the central part of the township to the southern part where the ridge enters Coshocton County. The clay ranges from 3 to 6 feet in thickness and the lower portion of the bed is very sandy and micaceous.

ECONOMIC VALUE

The Brookville clay is a very important mineral resource of Holmes County. The clay is present in every township except Washington and is a very steady and persistent member. Its position is at places near ridgetops from which the clay could be mined by stripping. Where the overburden is greater, drift mining would have the advantage of the Brookville coal for a roof, or if the coal were also used, the Putnam Hill limestone would form a satisfactory roof. The sandy material below the clay would be a satisfactory floor.

As already noted, the average thickness of the clay is 6 feet 5 inches, this thickness being exceeded at many places. The lower part is more siliceous than the upper, and for some purposes it would be desirable to remove only the upper part of the clay. In the north central part of the county the overlying Brookville coal is of sufficient thickness to provide a source of fuel for burning ware, but elsewhere other fuel must be used.

In Ohio the Brookville clay is used for high-grade building brick and block. With proper selection of parts of the bed, a very light-colored ware could be produced. Alone or with other clays it is satisfactory for stoneware and similar pottery. Although in general in Ohio the Brookville clay is not as satisfactory in working properties as some other clays for sewer pipe manufacture, the Brookville from Holmes County appears to be suitable for such fabrication. The test given below of this clay from Holmes County indicates it to be more satisfactory for intermediate heat duty refractories than is Brookville clay in some other parts of the State.

The clay was formerly mined by drifting both north and south of the Holmes-Wayne county line, three-fourths mile southwest of Fredericksburg, by the Mount Cherry Coal and Clay Company for the manufacture of brick and building block. This plant was located just south of the county line in NE¼ Sec. 25, Prairie Township. Nearer Fredericksburg, building block was also formerly made from Brookville clay by the Sampson Brick & Clay Company. Both companies used the Brookville coal over the clay for fuel purposes. The following tests of the Brookville clay from the mine of the Mount Cherry Coal and Clay Company have been made by the Geological Survey:[1]

[1] Stout, W. and others, Coal Formation Clays of Ohio: Geol. Survey Ohio Bull. 26, pp. 233, 284, 1923.

Tests of Brookville clay from mines of the Mount Cherry Coal Co., Fredericksburg, Holmes County.

Chemical Analysis		*Percentage oxide ratio*			
Loss at 105° C	2.09	K_2O	.063)		
Ignition loss	10.13	Na_2O	.010)		
Silica SiO_2	51.31	CaO	.013)		(SiO_2 1.807
Alumina, Al_2O_3	28.39	MgO	.021)	Al_2O_3 1.00	(TiO_2 .071
Ferric oxide, Fe_2O_3	2.95	FeO	.094)		(P_2O_5 .000
Lime, CaO	.38	Mno	.000)		
Magnesia, MgO	.60				
Titanic oxide, TiO_2	2.01	RO	.201		
Phosphorus pentoxide, P_2O_5	.01				
Sodium oxide, Na_2O	.28				
Potassium oxide, K_2O	1.78				
Manganous oxide, MnO	.01				
Sulphur, S	1.00				
Total carbon, C	.75				
Inorganic carbon, C	.00				

Mineralogical Examination

In sand separate, quartz is fairly plentiful in large and small primary grains. Brown pure clay aggregates are very abundant and also impure quartz-clay-sericite aggregates. Pyrite is fairly common as very small cubes imbedded in the impure clay aggregates. Muscovite is present as clear flakes. Other minerals present in the sand separate but in much smaller quantities are siderite, tourmaline, zircon, and rutile.

The clay separate carries sericite, quartz, and rutile in fine needles; calcite is present as small rounded grains; pyrite as separate crystals; while zircon and tourmaline occasionally are noted.

Physical tests

Working properties: Fair degree of plasticity. Molding properties good.

Tempering water	17.31%
Drying linear shrinkage	4.41
Drying volume shrinkage	13.83

Burning behavior

Burning temperature	Per cent linear shrinkage	Per cent volume shrinkage	Per cent volume absorption	Color
Cone 08	2.02	5.95	21.32	Cream
Cone 03	3.38	9.81	10.17	Cream
Cone 2	4.64	13.28	19.89	Light buff
Cone 4	5.33	15.14	17.71	Medium buff
Cone 7	6.10	17.20	14.80	Medium buff
Cone 10	5.09	14.51	10.27	Light gray buff
Cone 13	3.11	9.06	3.16	Brown gray speckled
Cone 14	0.95	2.81	1.40	Brown

Overburning temperature: Cone 14 (1,410° C. or 2,570° F.)

Best apparent burning range Cones 4 to 10 (1,210° C. to 1,330° C. or 2,210° F. to 2,426° F.).

Total linear shrinkage at cone 10, 9.50%.

Deformation temperature: Cone 29 (1,650° C. or 3,002° F.).

Possibilities: Intermediate heat duty refractories, face brick, sewer pipe, hollow block, fire proofing.

ALLEGHENY FORMATION

The Allegheny formation overlies the Pottsville and is the highest formation in Holmes County. Its full thickness is not present in the county, as the highest member, the Upper Freeport coal, is nowhere preserved. The next highest member, the Lower Freeport coal, is present in a few of the highest knobs in the eastern part of the county but the highest member of wide distribution is the Middle Kittanning coal and its accompanying marine roof shale, the Washingtonville member. The extent of the Allegheny formation is shown on the geologic map of Holmes County.

The Allegheny formation is composed in large proportion of shale and sandstone, as is the underlying Pottsville. One important limestone, the Putnam Hill; several coal beds of which three are widespread and important, the Brookville, Lower Kittanning, and Middle Kittanning; and two important clay beds, those under the Kittanning coals, are important members but of subordinate total thickness.

The base of the Allegheny formation is the base of the Brookville coal, the underlying clay being the uppermost Pottsville member. This division is arbitrary and not based on change in the character of cyclic sedimentation. It does not come at a division between two cyclothems.[1] It does, however, provide a convenient unit of Pennsylvanian rocks for mapping purposes and is sanctioned by long usage by many geological surveys, national and state. An average section of the Allegheny members follows and is also shown graphically on the geologic map of Holmes County.

Average Section of Allegheny Formation in Holmes County

		Ft.	In.
	Shale	9	7
Lower Freeport	Coal, locally present	1	1
Lower Freeport	Clay, plastic, siliceous, local	4	0
	Shale, gray to buff, siliceous, sandstone locally present	49	8
Washingtonville	Shale, carbonaceous, fossiliferous	1	8
Middle Kittanning	Coal, persistent	2	0
Middle Kittanning	Clay, plastic, impure	3	10
	Sandstone, coarse, massive, locally replaced by shale	36	5
Hamden	Shale, carbonaceous, calcareous and fossiliferous; locally absent	1	1
Lower Kittanning	Coal, persistent	2	1
Lower Kittanning	Clay, plastic, fair quality	5	4
	Shale, siliceous	13	9
(*Vanport*)	(Limestone, greenish tan, very ferruginous, very rare)	1	3
	Clay shale, gray to buff, with ore in nodules	16	0

[1] Wanless, H. R., Pennsylvanian Cycles in Western Illinois: Illinois Geol. Survey Bull. 60, pp. 179-193, 1931.

		Ft.	In.
Putnam Hill	Limestone, blue gray, fossiliferous; extremely persistent	3	4½
	Clay shale	0	2½
Brookville	Coal, fair	0	6
	Clay shale, dark	0	2
	Coal, fair	0	9
	Total	155	0

BROOKVILLE COAL

STRATIGRAPHY AND EXTENT

The Brookville or No. 4 coal is the basal member of the Allegheny formation. It has been traced from Pennsylvania southwestward across Ohio into Kentucky. In much of Ohio the Putnam Hill limestone is found directly over this coal, which aids greatly in the identification and location of the bed. This coal is at its best in Stark County,[1] and is of some importance in Holmes, Wayne, Tuscarawas, Coshocton, and Vinton counties. It is not one of the important coal beds of the State, but it does furnish much fuel for local use in the counties named and occasionally in others along its outcrop.

In Holmes County the Brookville coal has been mined in a small way at several places in Prairie and Salt Creek townships and was formerly mined near Fredericksburg in Salt Creek Township, Wayne County, together with the underlying clay, the coal being used to burn the clay. This coal is present in all the townships of the county except Washington, where its presence is doubtful. It is always found where due, except in a few small areas where sandstone has replaced it and the accompanying Putnam Hill limestone. In places other than Salt Creek, Prairie, and a small part of Hardy townships and rare tiny areas elsewhere it is so thin that it will never be of economic importance.

The Brookville coal lies beneath the Putnam Hill limestone, 2 to 3 inches of gray shale separating the two. On the average, it lies 25 feet 6 inches above the thin Tionesta coal and 54 feet 3 inches above the Bedford coal. The thickness and structure of the Brookville coal are very steady over large areas. The average thickness of the benches and the main parting is:

	Ft.	In.
Coal, poor to fair	0	6
Clay shale, dark	0	2
Coal, fair to good	0	9

The greatest thickness observed is 3 feet 6 inches in northeastern Prairie Township, and the least, 2 inches. The bed is everywhere divided into two main benches; an upper, which is generally thinner, containing more impurities; and a lower, thicker one of better quality. The benches

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, pp. 29, 30, 1930.

are separated by a parting, commonly 2 or 3 inches of black clay shale. Locally pyrite knots or streaks are found in the bed. The top of the upper bench is generally bony, especially in the thicker deposits.

Because the bed is of economic importance in only a few of the townships and because it is associated with the Putnam Hill limestone, the location of the coal bed is not given in great detail as it is not such an important horizon marker as the overlying limestone. As its base is the plane of contact between Pottsville and Allegheny formations its location is shown on the accompanying geologic map of the county. Some sections illustrating the thickness of the bed are given in the township descriptions; additional sections illustrative of the bed are found in the discussion of the Brookville clay and of the Putnam Hill limestone. The stratigraphic relations are illustrated in many of the longer sections in the Appendix.

Paint Township.—The Brookville coal is widely distributed over Paint Township, cropping out closer to the top than to the bottom of the hills and ridges, its place being marked by the very prominent Putnam Hill limestone which overlies the coal. In the extreme northeastern part of Paint Township, outcrops of the Putnam Hill limestone and the Brookville coal are obscured by glacial drift but the coal is known to be of fair thickness from exposures in S½ Sec. 32, Sugar Creek Township, Stark County, one-half mile south of Wilmot, where at an altitude of 1,160 feet the Brookville coal is 2 feet thick. In the northern part of Paint Township the coal is of fair quality but is thin, ranging from just less than to a little more than 1 foot in thickness. On the farm of A. T. Weaver, in SW¼ Sec. 26, 1 foot 4 inches of Brookville coal lies directly under the Putnam Hill limestone (2-229, Appendix). In NW¼SE¼ Sec. 27, on the farm of Joseph Nisley, where the Putnam Hill limestone has been quarried by Elvin Miller, the coal is reported to be 8 inches in thickness. In NW¼NW¼ Sec. 27, south of the crossroad at the county line, the Brookville coal has a thickness of 1 foot 7 inches (3-232).

In SE¼NE¼ Sec. 32, in a quarry on the farm of Howard Harrold, Brookville coal 10 inches thick is exposed below the Putnam Hill limestone. It therefore seems that in the northern part of Paint Township the Brookville coal although of fair quality is nowhere of minable thickness, except possibly in that part closest to the village of Wilmot in Stark County, from which part of the township no data are at hand.

In the southern part of Paint Township the Brookville coal is thinner than in the northern part, at few places reaching a thickness of more than 3 or 4 inches, and nowhere more than 1 foot (5-227). In the extreme southeastern corner of Paint Township south of Indian Trail Creek and in the central western part of Wayne Township, Tucarawas County, the Brookville coal is about 2 inches thick in most places. In the northwestern part of Wayne Township, Tuscarawas County, the

Brookville coal reaches a greater thickness but is too thin to mine. The following section measured in a road ditch one-half mile east of the Holmes County line and seven-eighths mile south of the Greenville Treaty Line is illustrative of the character of the bed in this part of Wayne Township and presumably it has about this character and thickness to the west in the eastern part of Paint Township, Holmes County.

	Ft.	In.
Clay shale, ferruginous	3	0
Limestone, loose blocks, *Putnam Hill*	2	0
Coal, weathered, *Brookville,* altitude 1,140 feet	1	5
Clay, light, plastic, siliceous	4	0

Salt Creek Township.—The Brookville coal is present beneath the Putnam Hill limestone in a large part of Salt Creek Township. In the eastern part of the township it is thin and unimportant but in the northwestern portion its thickness increases and this part of the township forms part of an area in northwestern Salt Creek, northeastern Prairie, southwestern Salt Creek Township of Wayne County, and southeastern Franklin Township of that county, where the Brookville coal assumes some importance as a source of fuel. This area in the adjacent corners of these four townships is the most important area of the Brookville coal in Wayne or Holmes County.

In the northeastern part of Salt Creek Township, outcrops of the Brookville coal are obscured by glacial drift but the coal is probably thin. In the central part of the township in Sec. 3 the Brookville coal crops out immediately under the Putnam Hill limestone at elevations ranging from 1,180 feet to 1,220 feet and is about 1 foot in thickness.

In the northwestern part of Salt Creek Township, in secs. 30, 31, 32, 33, 5, and 6, the Brookville coal is of sufficient thickness to mine. Its altitude ranges from 1,230 feet in Sec. 33 to 1,185 feet or a little less, 3 miles to the west in Sec. 31. The coal was formerly mined from beneath the Putnam Hill limestone on the farm of I. C. Cunningham in SE¼SE¼ Sec. 32, where the owner reports that the coal is 2 feet 2 inches in thickness. One-quarter mile to the northeast along the road in NW¼SW¼ Sec. 33, the following measurements illustrate the structure of the bed at this locality:

		Ft.	In.
Clay shale		5	0
Limestone, gray, platy, fossiliferous, dense, *Putnam Hill*		3	8
Coal, weathered	*Brookville,* altitude 1,230 feet	0	11
Clay shale, gray		0	3
Coal, weathered		1	4
Clay, siliceous, plastic		2	0

To the west the coal becomes somewhat thicker. In central Sec. 6 the coal is 2 feet 6 inches in thickness (13-59, Appendix) and in NE¼ Sec. 6 the coal is 3 feet in thickness. Where the Brookville coal has a greater thickness than average, the upper part of the top bench is generally bony. The typical structure of the thicker Brookville coal is well shown in the following section measured in an abandoned mine just west of the road in SE¼SE¼SE¼ Sec. 31:

		Ft.	In.
Covered		38	0
Limestone, massive, blue gray, *Putnam Hill*		6	0
Coal, bony	*Brookville*, altitude 1,190 feet	0	3
Coal, good		0	10
Shale, dark		0	1
Coal		0	4
Shale, dark		0	1
Coal, good		2	2
Clay, plastic		1	0

Brookville coal has been stripped in a small way just east of the section-line road in NW¼SW¼ Sec. 5, where the coal is about 2 feet 6 inches in thickness and has an altitude of 1,210 feet. A considerable area of Brookville coal together with the underlying clay is present just west of this locality in Sec. 6, where the coal and clay lie very close to the top of the hill. In SW¼SW¼ Sec. 30 the Brookville coal was formerly mined in a ravine, where it has a thickness of 2 feet 6 inches.

In the southwestern corner of Salt Creek Township, southwest of Martins Creek, the Brookville coal is hardly of sufficient thickness to mine. Along the road 1 mile south of Martinsville, at an altitude of 1,185 feet, a blossom of the Brookville coal 2 feet thick directly underlies the Putnam Hill limestone (14-13). Observations in Hardy Township to the south and Prairie Township to the west show that in this locality the Brookville coal ranges from 1 foot 6 inches to 2 feet in thickness, and that thicker coal under cover is hardly to be expected.

In the central southern part of Salt Creek Township the higher land just west of "The Plains" and 1 mile south of Fryburg is underlain by the Brookville coal. Near the top of the hill just south of the crossroad whose elevation is 1,122 feet, one-eighth mile north of the Salt Creek-Berlin township line, the Putnam Hill limestone has been quarried rather extensively for agricultural lime and some of the underlying Brookville coal has been removed from the quarry floor. The coal ranges in thickness from 2 feet 2 inches to 2 feet 6 inches and a fair amount of coal lies under thicker cover to the west.

Prairie Township.—The Brookville coal of any importance in Prairie Township is confined to secs. 25 and 26 in the northeastern part, just south of the Wayne County line. Elsewhere in the township it has been removed by erosion except from a small area of high land in the central southern part of the township lying between Paint Creek and Killbuck Creek. The Brookville coal and underlying clay have been mined from several openings in Sec. 25, the largest of these being worked formerly by the Mt. Holly Company which used the coal for burning the underlying clay into face brick. The plant is no longer in operation. It has also been used by the McDonald Clay Company just across the county line to the north in SE¼ Sec. 24, Franklin Township, Wayne County. In this locality the thickness of the coal ranges from 2 feet 4 inches to 3 feet (For section and analysis see under "Economic Value.")

In secs. 15 and 16 in the central southern part of the township, a few inches of Brookville coal underlies the Putnam Hill limestone at an altitude of about 1,130 feet. Here the coal is probably too thin to be mined (19-238).

Ripley Township.—The horizon of the Brookvile coal and the overlying Putnam Hill limestone has been removed by erosion from most of Ripley Township except in the central and southwestern parts, but outcrops are very scarce because of the thick covering of glacial drift. In the southwestern part of Ripley Township this part of the stratigraphic column is occupied by a coarse sandstone, except in Sec. 8, where at the top of the hill in the central part of this section a little weathered coal crops out at an elevation of 1,285 feet (22-357, Appendix).

Knox Township.—In Knox Township the Brookville coal is due under Bell Ridge in the eastern part and under the east-west ridge 2 miles south of Nashville. In one or two localities the Brookville coal reaches a fair thickness and has been mined. The coal was formerly mined in a ravine on the farm of Wallace Bell 200 yards southwest of the 1,303-foot road fork one-half mile west of the Monroe Township line and 2 miles south of the Ripley Township line (26-324). Mr. Bell states that in the mine the coal ranges from 18 inches to 30 inches in thickness and is of a good quality and burns satisfactorily.

The Brookville coal is of irregular thickness beneath the Putnam Hill limestone where quarried by the Nashville Lime and Stone Quarries Company on the farm of Harley H. Martin, one-fourth mile south of Stone School, 1¾ miles south-southeast of Nashville. At the west end of the quarry a 9-inch coal blossom is present, whereas at the east end, 6 inches of hard, bright coal crops out although the entire thickness of the bed is not exposed. It is reported that as much as 31 inches of coal has been encountered. Nothing is known of the Brookville coal westward along the high ridge, as outcrops are obscured. Two miles southwest of Nashville, along the Greer road, the thin coal measured in the following section is possibly Brookville; if so, the Putnam Hill limestone is replaced by sandstone, as it is in the southeastern part of the township:

	Ft.	In.
Sandstone	10	0
Clay shale, gray	0	6
Coal, shaly, *Brookville?* altitude, 1,280 feet	0	4
Clay, dark gray, somewhat carbonaceous	0	7

	Ft.	In.
Clay, light, sandy	3	6
Sandstone, white, shaly, micaceous	8	0
Sandstone, shaly to thin-bedded	20	0

Monroe Township.—Small areas of the Brookville coal and the overlying Putnam Hill limestone are found throughout Monroe Township except in the western part where these members are replaced by sandstone. In this township the coal is in general rather thin in the northern and central parts but somewhat thicker in the central southern and southeastern parts. In the northeastern part of Monroe Township 10 inches of Brookville coal is exposed below the Putnam Hill limestone at an altitude of about 1,190 feet along a road 1 mile south of Paint Creek five-eighths mile west of the Monroe-Hardy township line.

In the western central part of the township a small area of Putnam Hill limestone remains uneroded near the top of a hill on the farm of N. R. Power, where it has been quarried. It is reported that the coal underlying the limestone is 1 inch in thickness. Several small outliers of the beds at this horizon are present in the central southern part of Monroe Township about 1 mile southwest of Welcome, approximately 1,190 feet above sea level. Here the coal is of fair thickness and small quantities might be mined for local use. In two small areas about one-half mile north of the 1,190-foot crossroad, 1 mile southwest of Welcome, the bed lies so close to the top of the hill that some coal might be secured by stripping. The thickness and structure of the coal are as follows:

		Ft.	In.
Clay shale with a few ore balls		6	9
Limestone, gray, dense, *Putnam Hill*		2	6
Clay shale		0	5
Coal, fair, weathered	*Brookville,*	1	10½
Clay shale, gray	altitude	0	3
Coal, fair, somewhat weathered	1,190 feet	0	4
Clay, gray, plastic, siliceous		6	0
Clay and covered		5	0

In the southeastern part of Monroe Township, in the vicinity of Philips School and to the north, several outcrops of Brookville coal are present at elevations ranging from 1,170 feet to 1,210 feet. One mile north of Philips School 8 inches of Brookville coal is exposed. The member has the same thickness one-half mile east of that school. In the extreme southeastern corner of the township, however, the Brookville coal increases in thickness and has been mined in a small way from near the top of the hill one-half mile north of Killbuck Township and one-half mile west of Hardy Township. It is not known how thick the coal is in this mine but one-half mile southeast, at the Killbuck-Monroe township line, the Brookville coal has a thickness of 1 foot 8 inches and is somewhat shaly (142-285).

Hardy Township.—In Hardy Township the Brookville coal crops out in association with the Putnam Hill limestone in all quarters of the township. At most places in the township the coal is fairly thin, generally being less than 1 foot 6 inches in thickness, although at a few places it is thicker. No serious attempts have been made to mine the coal even for local use. In the northeastern corner of Hardy Township the Brookville coal ranges from 1 to 2 feet in thickness. In NE¼SE¼ Sec. 4 a 2-foot blossom of the Brookville coal is exposed immediately underneath the Putnam Hill limestone 1,190 feet above sea level (46-63, Appendix). Near the 1193-foot road fork in NW¼ Sec. 4 the Brookville coal has the same thickness (45-65).

To the west, in partial Sec. 5, the coal is thinner, being 1 foot 6 inches in thickness along the road in NW Sec. 5 (47-51), and 1 foot thick at a road fork near SW Sec. 5. At the northeast corner of Millersburg, 6 inches of Brookville coal crops out immediately under the Putnam Hill limestone, which has an altitude of 1,140 feet along the Benton road (57-124).

In the northwestern part of Hardy Township only the higher hilltops are underlain by Brookville coal and in all places where seen in this part of the township it is very thin, nowhere reaching a foot in thickness. In the southwestern part of Hardy Township the Brookville coal is very erratic in thickness, in some places it is but 2 or 3 inches thick and at others it reaches a considerable thickness. At several outcrops near the top of the ridge between Bear Run and Uhl Run the Brookville coal is very thin. In the ditch of the road along the top of this ridge, 1 mile east of the Monroe-Hardy township line, the Brookville coal is 7 inches in thickness and is separated from the overlying Putnam Hill limestone by 3 inches of clay shale (52-276). In a ravine which is at the head of Hardy Run, 1 mile east of Monroe Township and one-fourth mile north of Killbuck Township, the Brookville coal appears to be very thin where it underlies the Putnam Hill limestone at an elevation of 1,125 feet (54-290), but a core drill test one-eighth mile south penetrated 3 feet 9 inches of Brookville coal (55-401). The Brookville coal was formerly mined on the farm of M. V. B. Metcalf one-fourth mile north of the Killbuck Township line and 2 miles east of the Monroe Township line. Mr. Metcalf reports that the coal in this mine is 1 foot 10 inches in thickness and is overlain by 5 feet of Putnam Hill limestone.

In the southeastern part of Hardy Township the Brookville coal is generally thin. In NW¼NE¼ Sec. 17, however, the coal has a thickness of 1 foot 8 inches where it is exposed at the bottom of an abandoned quarry in the Putnam Hill limestone (61-24). To the south the thickness decreases, until in Sec. 24 the coal is 6 inches thick where it underlies the Putnam Hill limestone in a ravine at an altitude of 1,120 feet (63-41). North of Upper Sand Run the members at this horizon underlie the tops of the hills along the state road from Millersburg to Berlin. The altitude of the coal increases from 1,105 feet in SW¼ Sec. 15 to 1,150 in SE¼ SE¼ Sec. 14, near the Berlin Township line. In the former section the coal is but a few inches thick but it increases in thickness to the east, where in the bank of the state road in SE¼SE¼ Sec. 14, 1 foot 4 inches of weathered Brookville coal is separated from the overlying Putnam Hill limestone by 2 inches of clay shale (60-66).

Berlin Township.—In northern Berlin Township the outcrop of the Brookville coal is obscured by glacial drift, but in the central and southern parts of the township it can always be found where due immediately under the Putnam Hill limestone. Where seen in Berlin Township the Brookville coal is generally thin, although a thickness of 2 feet is reached at one or two places. In the southwestern part of Berlin Township the thickness of the Brookville coal varies considerably over short distances. Three-fourths mile northeast of Saltillo, just east of the 1,183-foot cross-road, a blossom of the Brookville coal 2 feet thick crops out in a road ditch immediately below the Putnam Hill limestone which here is exposed at an altitude of 1,156 feet. On the hills west of Doughty Creek, near the Mechanic-Berlin township line, the Brookville coal at most outcrops is about 6 inches in thickness.

The Brookville and associated members underlie the high land upon which the village of Berlin is built and crop out on all sides of the village. About a mile west of Berlin the Brookville coal is 6 inches in thickness where it is exposed at several places along the road and in Putnam Hill limestone quarries. North of the village one-half mile it is a bit thicker but of no importance. South of Berlin the coal probably does not reach 1 foot in thickness in any place.

In the southeastern part of Berlin Township the Brookville coal is not more than 1 foot in thickness and is thinner at many places. Two miles southeast of Berlin, one-fourth mile south of the 1,259-foot road fork on Sugar Creek road and one-fourth mile west of Walnut Creek Township, 9 inches of Brookville coal crops out in a road ditch at an altitude of 1,155 feet. Along the road 1½ miles south-southeast of Berlin and one-half mile south of the Sugar Creek road the position and character of the member are as follows:

	Ft.	In.
Sandstone, and covered	68	0
Coal blossom, *Lower Kittanning*	1	0
Shale, and covered	21	0
Limestone, darker than usual, *Putnam Hill*	2	0
Coal blossom, *Brookville*, altitude 1,160 feet	1	0
Clay, light, plastic, siliceous	3	0

Walnut Creek Township.—The Brookville coal and its accompanying clay are present well above drainage throughout all of Walnut Creek Township. Its position is well marked by the overlying Putnam Hill limestone. This coal is variable in thickness throughout the township, but it notably exceeds 1 foot at few places. Observations indicate that in no place is it thick enough to mine.

The Putnam Hill limestone with the Brookville coal below is found underlying the top of the ridge in the northern part of Walnut Creek Township, where the coal crops out at elevations ranging from 1,120 to 1,140 feet. Several outcrops are present in road ditches in the vicinity of the crossroad in the central northern part of Walnut Creek Township 1 mile south of Trail (77-203, Appendix).

In the northwestern part of Walnut Creek Township the Brookville coal seems to be very thin, only 1 inch being present underneath the Putnam Hill limestone in central Sec. 8 in a ravine (81-224,). In the southwestern part of Walnut Creek Township the Brookville coal in its characteristic two benches ranges from 1 foot to 1 foot 6 inches in thickness (83-99).

The Brookville coal crops out below the Putnam Hill limestone at many places along the east-west ridge upon which Walnut Creek village is located, at altitudes ranging from 1,105 to 1,115 feet. The upper bench is commonly 4 or 5 inches and the lower from 5 to 8 inches in thickness (88-106 and 87-107). Along the relocated Walnut Creek-Trail road from 1 to 2 miles north of Walnut Creek village, outcrops of the Brookville coal show that the coal is from 2 to 4 inches thick (79-216).

In the southeastern corner of Walnut Creek Township the Brookville coal crops out at altitudes from 1,090 to 1,100 feet. The two benches in this corner of the township ordinarily have a combined thickness of more than 1 foot (93-134) and in NE¼NW¼ Sec. 1, two miles south of Walnut Creek village, a thickness of 2 feet was noted (91-183).

Clark Township.—In Clark Township the Brookville coal is exposed near the bottom of the valley of Sugar Creek and its tributaries in the central and southeastern parts of the township, but in the western part of the township it is higher above drainage. Where well exposed the coal is seen to consist of two benches with a total thickness of about 1 foot. In the northeastern corner of the township along the county line the following section was measured in the ditch of the state road in NW¼SW¼ Sec. 8, Sugar Creek Township, Tuscarawas County:

		Ft.	In.
Shale		25	0
Limestone, loose pieces; and covered, *Putnam Hill*		1	0
Coal, poor	*Brookville,* altitude 1,060 feet	0	3
Clay shale, dark		0	1½
Coal, fair		0	8
Clay, siliceous		4	6
Shale, sandy		17	0
Shale, soft		6	0

		Ft.	In.
Shale, dark, carbonaceous	*Tionesta*	0	3
Coal, fair	*Tionesta*	0	3
Clay, impure		5	2
Clay shale		4	0
Covered		3	6

In the valley of Troyer Valley Creek in the eastern and north central portions of the township the outcrop of the coal ranges from 1,040 feet in the mouth of the valley to 1,080 feet at Unionville, the coal rising about as fast as the stream rises. In this valley the thickness of the coal ranges from 6 inches to 1 foot. In the central northern part of the township the coal, with a thickness ranging from 6 inches to 1 foot, crops out underneath the Putnam Hill limestone at elevations ranging from 1,100 to 1,110 feet. In the northwestern portion of the township the upper bench of the member is a bit thicker and of a little better quality but the total thickness of the Brookville coal is generally not more than 1 foot.

In the central western part of Clark Township and in the central eastern portion of Mechanic Township the Brookville coal appears without the overlying Putnam Hill limestone. The coal has a thickness of about 1 foot (105-263, Appendix). In the southwestern part of the township the coal ranges in thickness from 1 foot (108-185) to a little more than 1 foot (109-186), where it is again associated with the Putnam Hill limestone.

In the valley of the south fork of Sugar Creek the elevation of the Brookville coal ranges from 1,100 feet in Sec. 18 in the southern part of the township to 1,035 feet in Sec. 16 in the eastern part, the rock strata dipping at about the same rate as the stream gradient. The following section secured along the road just north of the road forks in SE¼NE¼ Sec. 19 is illustrative of the Brookville coal in this part of the valley of South Fork:

		Ft.	In.
Shale, ferruginous		24	8
Limestone, blue gray, hard, dense, *Putnam Hill*		1	6
Clay shale, gray		0	2½
Coaly shale	*Brookville*	0	3
Clay shale, gray	*Brookville*	0	3
Coal, shaly	*Brookville*	0	5
Clay, and covered		5	0
Sandstone, white, clay-bonded		3	0
Covered		15	9
Road forks, altitude 1,019 feet.			

In the extreme southeastern corner of Clark Township, southeast of Sugar Creek, the Brookville coal is thin and unimportant. The overlying Putnam Hill limestone is also thin and impure and is at places wanting (113-150).

Mechanic Township.—The Brookville coal is well distributed throughout Mechanic Township, being absent by erosion principally from the central and central southern portions of the area. Elsewhere it can generally be found where due, everywhere accompanied by the overlying Putnam Hill limestone, except in a small area in the central eastern portion. In Mechanic Township the Brookville coal is variable in thickness and quality, generally being thin and poor in quality but at a few places reaching a thickness of from 1 foot 6 inches to 2 feet or more and being of fair quality. At one or two places in the township small attempts at mining the coal have been made.

In the northeastern portion of Mechanic Township the Brookville coal is variable as to thickness. In Sec. 1 and E Sec. 2 the coal crops out immediately under the Putnam Hill limestone at an elevation of approximately 1,130 feet and ranges in thickness from 6 inches to 1 foot. In E½SW¼ Sec. 2, however, a small area southeast of Deetz School is underlain by 2 feet or more of Brookville coal (126-112, Appendix).

One mile southwest of the above outcrop, in NW¼NW¼ Sec. 8, the Brookville coal crops out along a road. (This area of Brookville coal is not shown on the geologic map.) The following structure is shown at this place:

		Ft.	In.
Limestone, *Putnam Hill*, altitude 1,140 feet		2	0
Clay shale		0	2
Coal, fair	*Brookville*	0	8
Clay shale, dark	*Brookville*	0	1
Coal, fair	*Brookville*	0	9
Clay, light, plastic		6	0

In the central northern and northwestern parts of the township the Brookville coal has fair thickness. One mile southwest of Saltillo Brookville coal 1 foot 9 inches thick crops out along the road at an altitude of approximately 1,120 feet (128-40). To the south, in the vicinity of Webster Hall School, several outcrops of the Brookville coal have a thickness of from 1 foot to 1 foot 3 inches. It is reported, however, that in a ravine just west of Webster Hall School the coal is somewhat thicker and an attempt was made to mine it. In NW¼ Sec. 1, along the road up Sand Run Hill, 11 inches of Brookville coal is present beneath the Putnam Hill limestone at an elevation of approximately 1,100 feet. The coal becomes somewhat thicker to the west, where in SW¼SE¼NE¼ Sec. 2, in the northwestern corner of Mechanic Township, the Brookville coal has been mined in a small way on the farm of Henry Hubner. In this locality the upper bench of the Brookville coal is the one which increases in thickness as is shown by the following measurements made 20 feet from the mouth of Mr. Hubner's mine:

			Ft.	In.
Limestone, *Putnam Hill,* altitude 1,075 feet			1	0
Shale, dark			0	6
Coal, shaly	Brookville		0	2
Coal, good	Brookville		1	7
Shale, gray	Brookville		0	5
Coal, fair	Brookville		0	5
Coal, bony; with some pyrite	Brookville		0	2
Clay, plastic			2	0

In the central western and southwestern parts of Mechanic Township the Brookville coal is close to the tops of the hills. It has a thickness of 1 foot 2 inches where it crops out along the road at an altitude of approximately 1,090 feet in NW¼SW¼ Sec. 12. Several small areas are present in Sec. 19, the altitude of whose outcrop is approximately 1,090 feet. The thickness here is not over 1 foot. In the northern part of Sec. 20 at an altitude of 1,065 feet a small area remains at the top of the hill over which the Millersburg-Coshocton road passes. The thickness of the coal here is 1 foot 6 inches, the lower 6 inches being very shaly and impure. One-half mile north in NW¼SE¼ Sec. 11, just west of the crossroad, the following measurements were made:

	Ft.	In.
Crossroad,, altitude 1,063 feet.		
Shale and covered	33	0
Limestone, (not full thickness), *Putnam Hill*	2	0
Shale	0	6
Coal blossom, *Brookville*	2	0
Clay, and covered	7	6
Sandstone, white, shaly	2	0
Sandstone, shaly; and covered	32	0
Sandstone, shaly	16	6

In the central southern portions of Mechanic Township, Doughty Creek and its tributaries have reduced the surface below the horizon of the Brookville coal. In the eastern and southeastern portions small areas of this member remain in the vicinity of Becks Mills and to the south of this hamlet. In the central eastern portion of Mechanic Township in E½ Sec. 11, along the east-west road, about one-half mile east of Becks Mills at an altitude of 1,120 feet the Brookville coal, having a thickness of less than 1 foot, is not accompanied by the Putnam Hill limestone as is the almost universal case throughout Holmes County. In the southeastern corner of the township the horizon under discussion is present only near the tops of the highest hills and is very thin and found only with difficulty.

Killbuck Township.—In Killbuck Township the Brookville coal and the accompanying Putnam Hill limestone are found only near the tops of the highest hills, except in the central eastern portion of the township, because of the erosion of Killbuck Creek and its tributaries. In the northeastern part of Killbuck Township small areas in secs. 4 and 5 are underlain by the Putnam Hill limestone. The Brookville coal here is poorly exposed and no satisfactory measurements were secured. However, core drilling north of the township line in which 3 feet 9 inches of Brookville coal was penetrated indicates that Brookville coal of fair thickness may be present very close to the surface in an area in NE¼ Sec. 5 and NW¼ Sec. 4 (55-401, Appendix).

The northwestern portion of Killbuck Township between Shrimplin and Wolf creeks has been eroded below the level of the Brookville horizon. In the extreme southwestern corner of the township in S½ Sec. 23 a small area is underlain by this member at an altitude of approximately 1,190 feet. Although the underlying clay is very thick here, as mentioned previously, the coal is only a few inches in thickness.

The largest area in the township underlain by the Brookville coal is in the central eastern part in secs. 8, 13, and 14, where the coal lies underneath the Putnam Hill limestone at an altitude ranging from 1,100 to 1,120 feet. In Sec. 14 the coal appears to be very thin, but to the east it increases somewhat in thickness, where in SE¼NW¼ Sec. 13 along a road, 1 foot 2 inches of Brookville coal crops out at an altitude of approximately 1,100 feet (150-69). In those small areas in the southeastern part of Killbuck Township in E½ Sec. 18 and in Sec. 23, the thickness of the coal is not more than 1 foot and generally not more than 6 or 8 inches.

Richland Township.—In Richland Township the Brookville coal is of slight importance. The horizon of the coal remains uneroded only in the central and central southern parts and in a very small area in the extreme southeastern part. Coal, believed to be Brookville because of its structure, but without the accompanying overlying Putnam Hill limestone, crops out near the road forks in SE¼NE¼ Sec. 13, one mile east of the Pennsylvania Railroad. (This area is not shown on the geologic map of the county as the possibility exists the coal may be Tionesta, 164-364, Appendix.) The strata exposed in a road ditch are as follows:

		Ft.	In.
Shale, sandy		15	0
Clay shale, with ore balls		5	0
Coal, shaly	*Brookville*	0	6
Clay shale, dark	*Brookville*	0	2
Coal, shaly	*Brookville*	0	5
Clay, sandy		3	6
Sandstone, clay-bonded, shaly, white		8	0

On French Ridge 1½ miles south and southeast of the above outcrop, the Brookville coal is present, overlain by the Putnam Hill limestone. The character of the coal is shown by the following data secured one-fourth mile north of Election School in SW¼NW¼NE¼ Sec. 19:

	Ft.	In.
Limestone, brownish gray, slightly granular, fossiliferous, *Putnam Hill*	1	6
Clay shale	0	1½

		Ft.	In.
Shale, coal	*Brookville,* altitude 1,250 feet	0	¾
Clay shale		0	2
Coal, fair, weathered		1	1
Clay, light, siliceous to sandy; containing some muscovite		4	6

The Brookville coal maintains about this thickness and character in SE¼ Sec. 12 to the northeast. Farther east along French Ridge the horizon of the Putnam Hill limestone and of the Brookville coal is occupied by the upper part of the massive Homewood sandstone. In the central southern part of Richland Township in SE¼SE¼ Sec. 23 at the Holmes-Coshocton county line, the Brookville coal is represented by 4 feet 6 inches of dark, carbonaceous clay (168-374). Along the road one-fourth mile north of the county line in SE¼ Sec. 23, the following measurements were secured:

	Ft.	In.
Limestone, gray, fossiliferous, dense; loose pieces, *Putnam Hill,* altitude 1,250 feet	0	6
Coal, very shaly; or coaly shale, *Brookville*	2	5
Clay, gray, siliceous	4	9
Sandstone, white, clay-bonded	8	0

ECONOMIC VALUE

The Brookville coal has been mined in a small way principally in northeastern Prairie and northwestern Salt Creek townships, which is the area of most continuous coal that approaches minable thickness. Another small area in which Brookville coal may possibly have minable thickness is in northwestern Killbuck, southwestern Hardy, and southeastern Monroe townships (55-401). Still another small area lies in northeastern Knox Township (26-324). Elsewhere this coal, though very persistent, at few places exceeds 1 foot in thickness.

The Brookville coal normally occurs in two benches of approximately equal thickness separated by a parting of from 1 to several inches of shale. The roof is the Putnam Hill limestone. The floor is plastic clay which has more economic value than the overlying coal.

The Brookville coal is bright banded bituminous coal. It burns with a long flame, making it suitable for use in burning ceramic ware. No analyses of the bed from Holmes County are available, but the following analysis from about 300 yards north of the Holmes-Wayne county line is no doubt characteristic of the coal from nearby Prairie and Salt Creek townships of Holmes County. The sample was taken in 1926 from the mine of the Monroeville Clay Products Co. in SW¼ Sec. 24, Franklin Township, Wayne County, by T. R. Meyers and G. W. White. Analysis by D. J. Demorest.[1]

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, p. 31, 1929.

		Ft.	In.
Limestone, *Putnam Hill.*			
Shale, calcareous		0	½
Coal, sampled	*Brookville*	0	6½
Shale, rejected	*Brookville*	0	¼
Coal, sampled	*Brookville*	0	2¾
Mother coal, sampled	*Brookville*	0	¼
Coal, sampled	*Brookville*	0	3½
Shale, dark, rejected	*Brookville*	0	2½
Coal, sampled	*Brookville*	1	5¼
Shale, black, sampled	*Brookville*	0	¼
Coal, sampled	*Brookville*	0	3½
Clay		4	0

Proximate analysis

	As received	Moisture free
Moisture	6.81	0.00
Volatile matter	42.64	45.76
Fixed carbon	40.54	43.50
Ash	10.01	10.74
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	64.53	69.24
Hydrogen	5.55	5.14
Oxygen	15.87	10.55
Nitrogen	.76	.81
Sulphur	3.28	3.52
Ash	10.01	10.74
	100.00	100.00

Air drying loss 2.03 per cent

		As received	Moisture free
Heating value	Calories	6,548	7,027
	B. t. u.	11,787	12,649
Fusion of ash	Incipient	2,300°F.	
	Complete	2,399°F.	

Capacity of mine, about 25 tons per day.

PUTNAM HILL LIMESTONE

STRATIGRAPHY AND EXTENT

The Putnam Hill limestone is the most important limestone and the most useful stratigraphic horizon marker in Holmes County. The Putnam Hill, which is wholly an Ohio member, crops out over a large area in an interior field including parts of Stark, Wayne, Holmes, Tuscarawas, Coshocton, Muskingum, Licking, and Perry counties, and in a modified form in southern Vinton and in Jackson county.[1] It was named by Andrews [2] in 1870, from exposures on Putnam Hill in Zanesville.

The Putnam Hill member crops out in every township of Holmes County except Washington and Ripley. In all except Ripley, parts of Knox, parts of Richland, and in a small area in Mechanic and Clark townships, this bed is always present where due, presenting its typical appearance and acting as a stratigraphic guide. Not only is it usually present but its outcrops are almost always easily found along roads, (due

[1] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 170, 1927.
[2] Andrews, E. B., Report of Progress in 1869: Geol. Survey Ohio, p. 8, 1871.

to the distinctive shales above and the white, sandy shales a few feet below), and even in fields. Many small quarries for agricultural limestone give a clue to its presence. Strangely, its outcrop is generally obscured in small stream beds and in ravines, which is in contrast to the Lower Mercer member in such locations, where the latter forms small falls in many streams.

The structural and topographic features of the county contribute to the wide outcrop of the Putnam Hill member. In the western part, from which it normally should have long since been eroded, the highest land in the county is found, and hence this bed is still present. In the eastern portion the general east-southeast dip of the layers is much lessened, and in some areas is reversed, which structural condition serves to keep the Putnam Hill above drainage in this part of the county. Hence the wide-spread area where this bed is seen at the surface.

The thickness of the Putnam Hill limestone in Holmes County ranges from 6 inches to 12 feet. Thicknesses of more than 5 feet or of less than 2 feet are observed at few places. An average thickness of 3 feet 4½ inches for this important member is derived from 93 measurements throughout the county. The stratigraphic position of the Putnam Hill is just above the Brookville coal, the basal member of the Allegheny formation, from which it is separated almost everywhere by about 2 inches of gray clay shale. On the average the Putnam Hill limestone is 55 feet 8 inches above the Bedford coal and 78 feet 9 inches above the Lower Mercer limestone. An average of 69 measurements from the Putnam Hill limestone to the Lower Kittanning coal, the next widespread formation of later age, gives 39 feet 8 inches as the distance from the coal to the limestone. An average of 33 measurements shows that the Middle Kittanning coal is 83 feet 1 inch above the limestone.

The Putnam Hill limestone is very steady in thickness and characteristics throughout most of Holmes County. At most outcrops this limestone is dove gray, dense, hard, somewhat fossiliferous limestone. The dove gray color may at places be a bluish gray color, but it can rarely be spoken of as a blue limestone. Throughout the county this bed has the common name of the "gray limestone" or "gray lime," by which it is well known to almost every landowner in the vicinity of any outcrop. Where freshly exposed, the limestone generally consists of one massive bed. The top few inches may contain a noticeable amount of iron carbonate, and locally an inch or two of iron ore occurs at the top of the bed. At weathered outcrops the gray color has changed, due to the oxidation of the iron in the limestone, to a soft brownish or tan tone. Where pieces which have undergone weathering as a whole are broken, the tan shade can be seen as a concentric shell advancing into the interior of the mass. On weathering, the Putnam Hill limestone breaks up into thin, rather irregular, flat plates. In quarries near hilltops, some ground-water solution may have gone on along the joints and between bedding planes; and in such localities, slabs of the limestone, 2 or 3 feet square and from 2 to 4 or 5 inches thick, can be pried out with crowbars.

Under favorable circumstances the base of the limestone may be marked by a line of springs. In certain localities houses which were built a long time ago before the complete settling of the county were often located along hillsides near the springs rather than arranged with any relation to existing roads. The water, of course, percolates down through the shale above the limestone, through the limestone by means of joint cracks, and is then stopped from proceeding downward by the clay underneath the limestone or by the clay underneath the Brookville coal and the water is forced to migrate laterally until it reaches the side of a hill. The water from such springs may have a noticeable iron taste from the ferruginous shales above, but normally this is not present in sufficient degree to be objectionable.

At some places north of the glacial boundary in Holmes County great slabs of the limestone may be seen either above or below the natural horizon of the bed. These have been plucked loose by the glacier in its advance, carried up or down hill and for an unknown distance laterally, and then dropped when the ice melted or when the material sloughed off the bottom of the ice. Some of these transported blocks stick out of the hillsides in such a natural manner that one is led to believe that this is the outcrop of the Putnam Hill limestone in place. Investigation soon shows, however, that the characteristic shales above the limestone, the Brookville coal, and white clay grading downward into white, clay-bonded sandstone beneath are not present in such places. The heterogeneous character of the associated glacial drift is also generally apparent. Some of these transported blocks are large enough to support small quarries where relatively large amounts of limestone may be removed for agricultural purposes. When the block is gone, the quarryman is astonished not to be able to find the limestone beyond a certain point.

Paint Township.—The Putnam Hill limestone is present in a considerable part of this township. The bed is present near the tops of most of the hills and about halfway up the sides of the high Winesburg Ridge. In the northern part of the township the bed is generally obscured by the thick covering of glacial drift, but sufficient outcrops are found to indicate the presence of the member underneath the drift covering. In the southern part, beyond the glacial boundary, the limestone crops out with greater persistency, as is to be expected.

The Putnam Hill member in Paint Township is of moderate thickness and of typical appearance: dense, dove gray, moderately fossiliferous, consisting of a single bed where unweathered. The bed in this township is from 17 to 45 feet below the Lower Kittanning coal, from 62 to 80 feet below the Middle Kittanning coal, 60 to 62 feet above the Bedford coal, and 84 feet above the Lower Mercer limestone. As usual, the overlying shale is ferruginous, and the Brookville coal below is present, but thin.

In NW¼NE¼ Sec. 36, blocks of the limestone lie at an elevation of approximately 1,120 feet along the lane one-fourth mile south of the state road, but no satisfactory exposure was found (1-228, Appendix). Sufficient quantity is present to warrant collection for burning the limestone for agricultural lime. However, about a mile to the east, in a cut along the road, three-fourths mile south of the village of Wilmot, in S½ Sec. 32, Sugar Creek Township, Stark County, the following section was measured:

		Ft.	In.
Clay shale, ferruginous		7	0
Limestone, *Putnam Hill,* altitude 1,160 feet		2	6
Clay shale, gray		0	3
Coal, shaly	*Brookville*	0	2½
Clay shale, dark	*Brookville*	0	2
Coal, fair	*Brookville*	1	9½
Clay, gray, plastic		3	0

The bed is present near the tops of the hills at an elevation of approximately 1,200 feet in NW¼ Sec. 35, in SW¼ Sec. 26, and along the northwest-southeast ridge in Sec. 27. Its elevation rises to about 1,230 feet in NW¼NW¼ Sec. 27. In this vicinity the limestone has a thickness of about 4 feet, as examined in the small quarry on the farm of A. T. Weaver in SW¼SW¼ Sec. 26 (2-229) and in SW¼NW¼SE¼ Sec. 27 in the quarry of Elvin Miller. In the Miller quarry the bed is platy, blue gray, and moderately fossiliferous. As it is near the hilltop, with only a few feet of clay shale cover, it is jointed into blocks measuring about 3 by 4 feet. The joints have separated, and clay 3 to 4 inches thick is present in them. The bed has weathered into irregular plates a few inches in thickness, facilitating quarrying.

The Putnam Hill is well exposed along the Winesburg-Mt. Eaton road, just south of the Wayne County line, in NW¼NW¼ Sec. 27, where a thickness of 3 feet 6 inches was measured (3-232). This thickness increases to 5 feet, less than a mile to the north in Wayne County.[1] The Putnam Hill is present at an elevation of approximately 1,240 feet, near the top of the hill in the adjacent corners of secs. 28, 29, 32, and 33. Following are the thickness and relations at the small quarry of Howard Harrold, where the rock is crushed for agricultural use, in SE¼NE¼ Sec. 32:

	Ft.	In.
Clay shale, with ore balls	10	0
Ore, shaly and calcareous, very fossiliferous	0	3
Limestone, hard, dense, blue gray, platy, (irregular), fossiliferous, *Putnam Hill*	4	6

[1] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, p. 114, 1921.

		Ft.	In.
Clay shale, gray		0	2
Coal, shaly	Brookville	0	1
Clay shale, dark gray	Brookville	0	3
Coal, fair	Brookville	0	9
Clay, light, plastic, siliceous.			

The presence of the ore overlying the limestone in the above locality is of interest, as an ore is not usually present over the limestone, and where it is, is rarely as thick as in this section. This shaly ore is an excellent bed from which to collect fossils because of their abundance and the ease of collecting from the shaly material.

In the northern part of the western tier of sections the Putnam Hill seems to be present, but no clear geologic sections could be secured, owing to the drift mantle. The limestone seems to be in place at an elevation of 1,200 feet, where the road crosses the spur of the upland in SW¼SW¼ Sec. 6, but the exposure is not clear enough for measurement. It is noteworthy that the elevation of the bed 2 miles to the northwest is 1,240 feet.

Entering the township at the southwest corner, the upland which has been called the "Winesburg Ridge" and which extends past Winesburg into Tuscarawas County, is underlain by the Putnam Hill member. The bed is exposed at many places along the southeastern side of the ridge which forms the northwestern wall of the valley of Indian Trail Creek. On the northwestern side of the ridge the terminal moraine masks the outcrop. The deep valley of a tributary to Indian Trail Creek has cut through the ridge just east of "Seven Lick Hill," one-half mile east of Easley School, thus exposing the limestone which has a thickness of 2 feet 8 inches (4-207). Other measurements taken along the ridge show that the thickness probably is not more than 3 feet in this part of the township.

One-quarter mile from the Holmes-Tuscarawas county line, in Wayne Township of the latter county, a prospect pit has been opened in the limestone on the farm of James G. Devore, seven-eighths mile south of the Greenville Treaty Line. The section is as follows:

	Ft.	In.
Clay shale, calcareous, with ore balls	10	0
Limestone, dense, gray, fossiliferous, *Putnam Hill*, altitude 1,140 feet	1	10
Clay shale	0	3
Coal, weathered, *Brookville*	1	5
Clay, light, plastic, siliceous	4	0

The Putnam Hill is present, where due, in Wayne Township of Tuscarawas County, and in Sugar Creek Township of Stark County, which townships join Paint Township, Holmes County, on the east.

Salt Creek Township.—The Putnam Hill marine stratum is present near the tops of the higher hills in the western part of this township; and in the eastern portions it underlies the north-south ridge upon which is located the village of Mt. Hope and the hamlet of Calamoutier.

In the northeastern part of Salt Creek Township, from Mt. Hope to Calamoutier, no clear exposures were seen because of the thickness of the glacial drift. Occasional indications of white, shaly sandstone, which lies under the limestone, and the ferruginous shale, which rests over the limestone, show that the elevation in this part of the area is a little more than 1,220 feet. One-half mile north of the township, in central Sec. 23, Salt Creek Township, Wayne County, Conrey reports that the limestone has a thickness of 4 feet and describes it as "gray, fossiliferous limestone."[1] As seen by the present writer it presents no difference from the typical Putnam Hill stratum in Holmes County.

In this township, the Putnam Hill has the same appearance as in Paint Township, but is thicker at most outcrops. The rock has been quarried and ground for local use on the farm of Eli J. Troyer, northwest of Guthrie School, in NE¼NE¼ Sec. 33, where it has a thickness of 3 feet 6 inches. In this quarry the limestone has a brownish cast due to weathering. Quarrying is easy because the stratum is weathered into thin, irregular plates, due to the thinness of the cover on the hilltop. A little less than a mile to the southwest, along the road in SW¼NW¼ Sec. 33, a thickness of 3 feet 8 inches was observed. Along the road between secs. 28 and 33, one-eighth mile east of the crossroad at the corners of secs. 28, 29, 32, and 33, the following data were secured:

	Ft.	In.
Clay shale	3	0
Limestone, gray, fossiliferous, "crinoidal," somewhat granular, lighter and softer gray than usual; not shaly, but irregularly bedded in places, *Putnam Hill*, altitude 1,235 feet	2	6
Coal; clay and covered	4	0
Sandstone, white, shaly	8	0
Shale, sandy	5	0

The thickness of this member increases to the west, as shown by the following observations (see also 12-138, Appendix) made at the small quarry above an abandoned mine in the Brookville coal, on the farm of I. C. Cunningham, in SE¼SE¼ Sec. 32:

	Ft.	In.
Clay shale and soil	3	0
Limestone, hard, gray, fossiliferous, *Putnam Hill*, altitude 1.225 feet	4	10
Clay	0	3
Coal, good, (reported by owner) *Brookville*	2	2
Clay, good, and covered	8	0
Shale, ferruginous, clay-like to siliceous; with lenses and nodules of ore	22	0

[1] *Ibid.*, p. 114.

To the west, in NE¼NE¼NE¼ Sec. 6, the thickness of the Putnam Hill has further increased, as shown by the figures obtained at an abandoned mine in the Brookville coal:

		Ft.	In.
Clay shale, ferruginous		8	0
Limestone, hard, gray, platy, fossiliferous, *Putnam Hill*, altitude 1,190 feet		6	5
Clay shale, gray		0	2
Coal	*Brookville*	0	9
Shale, dark, carbonaceous, with coaly streaks	*Brookville*	0	3
Coal	*Brookville*	1	11½
Clay, siliceous, plastic, apparently good		3	0

Interesting to relate, at this location above an old mine in the Brookville coal, several "sink holes" are present. These illustrate the weakness of the Putnam Hill limestone as a roof in most Brookville mines. The limestone is cut by two sets of vertical joints at right angles to each other. The joints of each set are generally 3 to 4 feet apart. The solution of ground water enlarges the joint cracks and the blocks fall. Once blocks have fallen, the soft shale above, where saturated with water, flows into the mine. In the locality under discussion, with 20 feet of overlying shale, these depressions are funnel shaped, and with the limestone visible at the bottom, have all the appearances of solution sink holes of a karst region.

The flat-topped ridge extending from central Sec. 6 to SW¼NW¼ Sec. 5 is underlain by the Putnam Hill marine member at an elevation of approximately 1,190 feet (13-59). Not more than 20 feet of shale covers the bed, except in one or two places, therefore stripping operations might be carried on to recover the limestone, the Brookville coal, and its clay.

The Putnam Hill crops out in the extreme southwestern part of the township near the top of the ridge southwest of Martins Creek, at an elevation of about 1,180 feet. Detailed measurements in this area were obtained across the township line in Hardy Township, and the stratum in this locality will be described under that township.

The hill, which rises between Martins Creek and The Plains, in the central part of the southern edge of Salt Creek Township, is high enough for the preservation of the limestone near the top at an elevation of a little less than 1,180 feet. The bed is well exposed where the Berlin-Fryburg road has been cut through the hilltop and where extensive quarrying operations have been carried on just west of the road. The rock has a good thickness and its weathering into slabs has made quarrying fairly easy. In the western part of the quarry, where the overburden is thicker and the amount of weathering less, the bed is much more massive, showing that in the fresh state the member consists of a single stratum. The underlying Brookville coal is of sufficient thickness to warrant removal from some parts of the quarry. A measurement of the limestone and coal gives the following:

	Ft.	In.
Drift and clay shale with iron concretions	5	0
Limestone, dense, gray to gray black, fossiliferous, *Putnam Hill*	5	6
Clay shale	0	3
Coal, fair, *Brookville,* altitude 1,170 feet	2	2
Clay, good	5	0
Sandstone, white, thin-bedded	3	0

In the central part of the township, west of the ridge on which Mt. Hope is located, are several hills which rise high enough to retain the limestone. The stone has been quarried for agricultural use in NE¼SW¼ Sec. 3, on the farm of Eli E. Mullet, where the limestone is 5 feet 4 inches thick (15-236). (For analysis see under "Economic Value." The members below the Brookville horizon were formerly exposed in the road cut below the quarry, on the eastern slope of the hill. Only a little more than one-fourth mile south-southeast of the Mullet quarry, along the road between secs. 3 and 10, the Putnam Hill lies at an elevation approximately 50 feet lower than at the Mullet quarry exposure. The lower outcrop seems to be in place, the characteristic ferruginous shales above are undisturbed; and the white shaly sandstone is below in its normal position.

Along the western slope of the north-south ridge which occupies the eastern part of the township, the Putnam Hill limestone has been quarried near the boundary line between secs. 2 and 3 in the southwestern part of fractional Sec. 11. Elsewhere along the sides of the ridge in Salt Creek Township and well into Berlin Township to the south, the layer is concealed beneath the drift. Doubtless prospects could easily find the stratum at an elevation of between 1,170 and 1,190 feet south of Mt. Hope.

Prairie Township.—The Putnam Hill member is confined to the tops of three of the highest hills in this township, one of which is in large part beyond the township boundary. The master stream of the county, Killbuck Creek, and two of its largest tributaries converge in Prairie Township, and hence most of the area has long since been eroded below the Putnam Hill horizon. The largest area of the bed underlies the high land in the northeastern part, west of Salt Creek, extending northward into Wayne County. This high land forms the divide between Killbuck Creek and Salt Creek. The limestone crops out at many places near the top of the slope of the west valley wall of the latter stream. The limestone has a thickness of about 3 feet in this area (16-54, Appendix).

In the central southern part of Prairie Township the ridge in Sec. 16 is capped by the Putnam Hill marine layer at an elevation of approximately 1,130 feet. Only weathered outcrops of 2 feet 6 inches of limestone are present, and these probably do not represent the full thickness of the bed under cover (19-238). Several very small areas of the Putnam

Hill limestone extend into the southeast corner of Prairie Township, but they are parts of a larger mass just to the south in Hardy Township, and will be mentioned under that township.

Ripley Township.—The horizon of the Putnam Hill limestone is due near the top of the ridge in secs. 7, 8, and 18 in southwestern Ripley Township, but the member was not observed. It is either concealed by glacial drift or its place in the column is occupied by sandstone.

Knox Township.—The Putnam Hill limestone in Knox Township is confined to a relatively small area in the northeastern portion. One and three-fourths miles south-southeast of Nashville, one-quarter mile south of Stone School, on the farm of H. H. Martin, an extensive quarry in the limestone is operated by the Nashville Lime and Stone Quarries Company, A. F. Radsvick, general manager. The stone is exceptionally hard and much darker and bluer than typical. (For analysis see under "Economic Value.") The top of the stratum, as uncovered in the quarry, rises 20 feet or more to the west in about 300 feet. The limestone at the west end of the quarry is 66 feet below the Middle Kittanning coal exposed in a strip mine one-fourth mile to the west, and 53 feet above the base of the Upper Mercer limestone which crops out in a ravine one-eighth mile south of the west end of the quarry, (25-396, Appendix.) A section in the quarry is measured as follows:

	Ft.	In.
Till, weathered	3	0
Shale, gray; with many ore balls and discs to 8 inches	8	0
Limestone, dark blue gray, very hard; in layers 6 inches to 2 feet thick, *Putnam Hill*, altitude 1,290 feet	8	1
Shale, gray, calcareous, very fossiliferous	0	9
Shale, black, carbonaceous, hard, very fossiliferous, fossils of white calcite	0	5
Coal, bright, hard; not full thickness, *Brookville*	0	6

One mile southeast of the Nashville Quarries Company opening, in a ravine just west of the road, 200 yards southwest of the 1,303-foot road fork, above an old opening in the Brookville coal, the Putnam Hill limestone is 2 feet 3 inches in thickness, at an elevation of 1,275 feet. Here the limestone lies 60 feet below the Middle Kittanning coal and 61 feet above the Lower Mercer limestone. The limestone is intermediate in character between typical, gray, platy limestone and the dark, bluish, massive phase of the Nashville quarry. It is fine-grained, and the upper few inches is ferruginous. It is overlain by more than 12 feet of sandstone (26-324).

To the south, on Bell Ridge, the Putnam Hill limestone was not observed; its place appears to be taken by sandstone. One and one-half to 2½ miles south and southwest of Nashville, one-half to 1 mile southwest of Jance School, the ridge is high enough to retain the limestone, but it is either replaced by sandstone or concealed by glacial drift.

Monroe Township.—The horizon of the Putnam Hill limestone remains at the tops of the higher hills in the eastern and western parts of this township. Elsewhere the surface is now eroded below this horizon. The stratum is apparently absent from the hills in the southwest portion through lack of deposition or through replacement by sandstone. The member presents its typical appearance in the township. Inferences relative to its state in the northwestern portion are mentioned below.

In the northeastern corner of Monroe Township the bed caps two or three hills, but the area is small. The hill which is 1 mile south of Paint Creek and three-fourths mile west of the Hardy-Monroe township line is just high enough to retain the limestone at an elevation of approximately 1,190 feet, the bed cropping out a few rods east of the crossroad.

The member is exposed along the bank of the Millersburg-Loudonville road, a little less than a mile from the Hardy-Monroe township line, at an elevation of about 1,180 feet. Here it is very close to the top of the hill and could easily be removed by stripping. A larger area of the rock underlies the hill to the southwest at about the same elevation. A measurement taken along the road, one-third mile south of the Millersburg-Loudonville road and 1 mile south of Johnson School shows:

	Ft.	In.
Clay shale, slightly ferruginous	3	0
Limestone, dove gray, hard, dense, platy, fossiliferous, *Putnam Hill*, altitude 1,180 feet	5	6
Clay shale, gray	0	2
Coal, weathered, *Brookville*	0	5
Clay, light, plastic, siliceous	3	2
Shale, white, sandy, ganister-like	6	0

Most of northern Monroe Township, because of its proximity to Paint Creek, has been eroded below the level of the Putnam Hill member. However, two tiny areas of the bed are preserved about one-fourth mile south of the Millersburg-Loudonville road, 2½ miles west of the Hardy Township line at an elevation of approximately 1,220 feet (33-316).

In the northwestern part of the township, the limestone has been quarried on the farm of N. R. Power, 1¾ miles east of Knox Township and 1⅞ miles south of Ripley Township. Here the bed is near the top of the hill, but many loose blocks are present on the hillside below the line where the member seems to be in place. This displacement is doubtless due to the action of the ice sheet, similar effects having been seen in other glaciated parts of the county. The limestone is crushed fine enough for 70 per cent of it to pass a 100-mesh screen, and is used locally. The following section was measured at the quarry:

	Ft.	In.
Soil	3	0
Limestone, gray, hard, dense, fossiliferous, platy, 1½-to-3-inch plates, *Putnam Hill*	5	1
Coal, (reported), *Brookville*	0	1

The presence of the bed capping another hill ½ mile to the west is reported, but was not seen. Farther to the west, near the Knox Township line, near the top of the high ridge which is an offshoot of Bell Ridge, the limestone was not seen. A coarse, massive sandstone occupies the horizon, and it is thought that the limestone was deposited, then eroded, and sandstone deposited after Putnam Hill time but before Middle Kittanning time. Thorough investigation of this ridge is hindered by the presence of thick drift deposits of morainic character. The replacement by sandstone continues into the southwestern part of the township, and for several miles farther southward in Richland Township.

In the central southern part of Monroe Township the bed is found near the tops of several hills. At the road fork 1 mile southwest of Welcome, a thickness of 3 feet 10 inches was measured (37-255).

The marine member under discussion is present near the hilltops in the southeastern part of the township, between Philips School and the Hardy Township line, where the stratum is thicker than elsewhere in Monroe Township. Its elevation one-quarter mile east of Philips School is approximately 1,200 feet, but it rapidly descends to about 1,130 feet 2 miles southeast in the extreme corner of the township. The following section was measured along the road 1 mile west of Hardy Township and 1½ miles north of Killbuck Township:

	Ft.	In.
Clay shale, with ore balls	2	0
Limestone, dove gray, hard, dense, fossiliferous, platy, *Putnam Hill*	7	4
Clay shale	1	0
Coal, shaly, weathered, *Brookville*	0	8
Clay, light, siliceous, plastic.		

Hardy Township.—The Putnam Hill limestone is found near the tops of the hills and ridges in this township. The outcrops are widespread, but the total area is small because Killbuck Creek and its tributaries have cut their valleys far below the horizon of the member leaving between the streams narrow, long ridges, which retain the bed near their tops. The elevation of the stratum is variable, on account of the large syncline whose axis trends north-south at about the position of Killbuck Creek.

In the extreme northeastern part of Hardy Township, the limestone crops out at elevations of from 1,190 to 1,180 feet. From this elevation the bed descends to the west at the rate of approximately 30 feet per mile until the axis of the syncline is reached. The thickness in this part of the township is above the average (46-63 Appendix). In NW¼ Sec. 4, the thickness of the member is 4 feet 3 inches (45-65) and in NW partial Sec. 5, 5 feet 2 inches (47-51). Just west of SW partial Sec. 5, where a road joins the Millersburg-Benton road from the west, the greatest thickness of the Putnam Hill limestone in Holmes County crops out. A bench mark, whose elevation is 1,128 feet, is present at about the base of the bed. The measurements secured follow:

	Ft.	In.
Limestone, dense, gray, fossiliferous, *Putnam Hill*	12	0
Coal, blossom, *Brookville*	1	0
Clay and covered	4	4
Coal, shaly, carbonaceous	0	3
Clay, light, sandy	2	9
Shale, sandy	11	0
Covered	8	0
Shale, sandy	10	0
Covered	10	0
Coal smut	0	2
Clay and covered	5	0
Coal, weathered, *Bedford*	1	8
Clay	3	0

Three small areas are present at the tops of hills near Gambles School, in the northwestern part of Hardy Township. Half a mile south of the school the member is exposed along the road at an elevation of approximately 1,160 feet, where the thickness is 2 feet (51-242). A quarter of a mile north of the school the elevation is approximately 1,170 feet and the thickness of the limestone 2 feet 7 inches (50-243).

The east-west ridge between Corns Run and Bear Run, in the central western part of Hardy Township, retains the limestone near its top, at an elevation of approximately 1,170 feet. Just east of the township line, one-fourth mile south of the state road, a quarry has been opened by the Holmes Agrilime Company, of which Charles Atha is general manager. Here the limestone is dove gray, dense, and near the outcrop weathered somewhat along joints and bedding planes. It ranges from 6 to 7 feet in thickness, with up to 4 inches of ferruginous limestone at the top of the member. Weathered shale containing ore knots overlies the limestone.

In the southwestern part of the township the hills rise higher than in the other parts, hence the limestone is farther from the tops of the ridges, and greater areas are preserved. The Putnam Hill has good thickness in this portion of the township. Along the road 1 mile east of the Monroe-Hardy township line, and 1 mile south of Bear Run, the limestone is 4 feet 8 inches thick. (52-276).

The largest continuous area of the Putnam Hill member underlies the ridge between Uhl Run and the Killbuck-Hardy township line. This ridge extends into Monroe Township on the west, into Killbuck Township on the south, and the two eastern branches are bounded by the wall of Killbuck Valley. The elevation of the bed rises from approximately 1,120 feet nearest Killbuck Valley to about 1,170 feet at the western part of the ridge. The thickness one-fourth mile north of the southern border of the township, one-fourth mile west of Killbuck Creek, on the farm of

M. V. B. Metcalf is reported by the owner to be 5 feet, with 1 foot 10 inches of the Brookville coal beneath. The coal was formerly mined here in a small way, and some limestone removed by Mr. Metcalf. The limestone is more than 6 feet in thickness 200 yards north of this small quarry (56-295). One mile west the limestone is 4 feet 11 inches thick as determined in a drill core (55-401).

Several areas of the Putnam Hill marine member are preserved very near the tops of the ridges in the central and southeastern portions of the township. Near the top of the hill over which the Benton road leads north from Millersburg, at the north corporation line of the village, the limestone has a thickness of just less than 5 feet (57-124).

The rock has been quarried for agricultural purposes at the top of the little knob which just reaches an elevation of 1,100 feet, at the corners of secs. 11, 15, 16, and 20. This is an outlier which was once a part of the much larger areas underlying the east-west ridge along which the state road runs to Berlin, and the northeast-southwest ridge running diagonally across Sec. 20. The character and thickness of the limestone are shown in the following section taken along the lane one-eighth mile south of the state road, where the lane crosses the line between secs. 11 and 15:

	Ft.	In.
Shale, and covered	9	0
Limestone, gray, *Putnam Hill*	5	2
Clay	0	2
Coal smut, *Brookville*	0	3
Clay, plastic, light, good	7	0
Sandstone, white, clay-bonded; and covered	5	0
Sandstone, thin-bedded to shaly; somewhat crossbedded	35	0

Where the road crosses the ridge in SW¼ Sec. 20, about 1 mile southeast of Millersburg, the bed is well exposed, having a thickness of 4 feet (58-122). The limestone has been quarried in NW¼SE¼ Sec. 17, where the thickness is 5 feet 2 inches. The elevation here is approximately 1,150 feet; the strata rising eastward 50 feet in the distance of 2 miles from the locality in Sec. 20.

Berlin Township.—Because of deep erosion by preglacial Martins Creek in northwestern Berlin Township, the Putnam Hill limestone is found mainly in the eastern and southwestern parts. In the northeastern part of the township the member underlies the ridge along the top of which is located the Berlin-Winesburg road. The outcrop along the western side of the ridge is obscured by glacial drift in Sec. 5 and N½ Sec. 6.

The member crops out along the road to Winesburg at the northeast corner of Berlin at an elevation of 1,167 feet. The limestone is also exposed just north of Berlin, about halfway between the top of the hill on which the village stands and the valley bottom (66-91, Appendix.) One mile west of Berlin the limestone is very close to the top of the ridge, because of the local eastward rise of the member and the decrease in height of the ridge. Here it has been quarried by Andrew Miller in considerable amounts, having been used for road metal and for agricultural purposes. A small part was burned to lime but most of it was crushed for direct application to fields. The following thicknesses and relationships were exhibited in the quarry:

	Ft.	In.
Soil	2	10
Limestone, gray, hard, dense, fossiliferous; platy on outcrop, *Putnam Hill,* altitude 1,182 feet	4	1
Clay shale	0	2
Coal, *Brookville*	0	3
Clay, light, plastic.		

This marine member underlies the hill just west of Buena Vista School in Sec. 8 in northwestern Berlin Township, at an altitude of 1,180 feet. The thicknesses and relationships exhibited here are similar to those which have been discussed in northeastern Hardy Township.

In southwestern Berlin Township the Putnam Hill limestone underlies the ridges about half way from the top, and outcrops are fairly common. Near the 1,183-foot crossroad three-fourths mile north-northeast of the village of Saltillo, the limestone has been quarried in a small way and burned for agricultural purposes. The following section is exposed in a ditch along the road just east of the crossroad:

	Ft.	In.
Sandstone	42	0
Clay, white, *Lower Kittanning*	3	0
Covered	15	6
Sandstone, white; and covered	8	0
Limestone, *Putnam Hill,* altitude 1,156 feet	3	0
Coal blossom, *Brookville*	2	0
Clay	3	0

In the southwestern corner of the township the limestone seems to be more fossiliferous than at most places. The thickness ranges from 3 to 4 feet, probably in more places being nearer the larger figure. Several excellent localities for fossil collecting are found along various road ditches and in many of the ravines. It may be noted that where the Putnam Hill member crosses a road of more than moderate slope, a distinct ledge is normally present. Pieces of the rock, ranging from small chips to slabs a foot or more square, generally "float" down the road for many feet. These chips are formed because of the platy character upon weathering, which is one of the distinguishing features of the member.

In southeastern Berlin Township the Putnam Hill limestone in many places is thinner than average. It is also harder, somewhat darker, and more ferruginous (73-86).

Walnut Creek Township.—The surface of Walnut Creek Township has been maturely dissected by Walnut Creek and its tributaries. It has been practically unaffected by glaciation. For these reasons outcrops can be found almost everywhere, and the bedrock of Walnut Creek Township can be studied in greater detail and with more completeness than in many of the other townships of Holmes County. Throughout most of the township the Putnam Hill limestone crops out about midway between the valley bottoms and the tops of the hills.

In the northeastern part of Walnut Creek Township, the limestone ranges from 2 feet to 2 feet 6 inches in thickness. Several good exposures are present near the 1,156-foot crossroad 1 mile south of the village of Trail. The following beds are exposed at the road fork one-fourth mile west of the crossroad:

		Ft.	In.
Clay shale; grading upward to siliceous shale, ferruginous		20	0
Limestone, gray, dense, platy, fossiliferous, *Putnam Hill*, altitude 1,140 feet		2	2
Clay shale		0	3
Coal, poor	*Brookville*	0	3
Clay shale	*Brookville*	0	2
Coal, fair	*Brookville*	0	9
Clay, gray, plastic, siliceous		4	6
Sandstone, white, clay-bonded, thin-bedded		5	0
Shale, sandy		10	0

In the northwestern part of the township the limestone is about 1 foot 6 inches in thickness and at most places is dove gray, dense, hard, and somewhat fossiliferous (81-224, Appendix).

In the southwestern part of Walnut Creek Township the Putnam Hill member is from 1 foot to 1 foot 6 inches in thickness. Near the village of Walnut Creek the bed has a thickness of about 3 feet (87-107).

In the southeastern part of Walnut Creek Township the member is present along the sides of the hills and ridges at an elevation of approximately 1,090 feet. The limestone is typical in appearance and ranges from 1 to 2 feet in thickness.

Clark Township.—The Putnam Hill limestone is above drainage along the sides of the valleys of the larger streams such as Sugar Creek and its tributaries—South Fork, Brush Run, Troyer Valley Creek, Walnut Creek—and at the headwaters of Mill Creek.

One mile west of the Tuscarawas-Holmes county line, along the boundary line between Clark and Walnut Creek townships, the Putnam Hill limestone passes under cover at an elevation of approximately 1,080 feet. At the hamlet of Unionville, in N½ Sec. 10, the limestone is exposed in the bed of Troyer Valley Creek. Here, the limestone and the underlying Brookville coal are as follows:

			Ft.	In.
Limestone, blue gray, hard, dense, fossiliferous	*Putnam Hill* altitude 1,080 feet		1	6
Limestone, darker gray blue, somewhat shaly			0	3
Clay shale, gray			0	1
Coal, fair	*Brookville*		0	2
Clay shale, dark			0	1
Coal, fair			0	10
Clay, light gray, plastic, siliceous			1	0

The marine stratum crops out near the bases of the hills in the vicinity of Farmerstown. One-half mile west of this village, along the road ditch north of the five corners in N½ Sec. 12, the 3 feet of limestone is well exposed (98-169). Northeast of Charm the limestone ranges in thickness from 1 foot 6 inches to 2 feet (100-117, 101-118).

In the western border of the township the Putnam Hill member is under cover in most of Sec. 6. In Sec. 15, it is represented by ferruginous shale, a rare occurrence in Holmes County (105-263). The limestone reappears in Sec. 16 where its elevation is approximately 1,100 feet.

In Sec. 25, in the southwest corner of Clark Township, the limestone was not observed in full thickness at any exposure, but from the presence of loose blocks is known to be present at an elevation of about 1,075 feet.

Along the road between secs. 19 and 22 in the central southern part of the township, near Flat Ridge School, the limestone which crops out at an elevation of 1,065 feet presents a different appearance from usual, being gray blue rather than dove gray and apparently containing a considerable amount of iron. Indeed, at this location the Putnam Hill approximates the Lower Mercer limestone in appearance. The measurements secured here follow:

		Ft.	In.
Clay shale with a few ore balls		20	0
Limestone, gray blue, hard, dense, atypical, *Putnam Hill*		2	0
Clay shale, gray		0	2½
Coal, shaly	*Brookville*	0	3
Clay shale, dark		0	3
Coal, shaly		0	6
Clay, siliceous; changing to white, clay-bonded sandstone toward bottom		6	0

At most exposures in the southeastern corner of Clark Township the Putnam Hill member has the same appearance as at the outcrop near Flat Ridge School. In central Sec. 16 the state road from Baltic to Sugar Creek has been relocated and along the abandoned part rain wash has gullied the road and uncovered the bedrock. Here the limestone is darker, bluer, and very granular, and has a nodular tendency. The overlying shale contains many iron nodules. The following section is exposed along the abandoned road:

		Ft.	In.
Shale, siliceous, with ore nodules		26	0
Shale, with iron nodules		8	0
Limestone, dark gray blue, hard, granular, fossiliferous, *Putnam Hill,* altitude 1.035 feet		1	0
Coal, poor, shaly	*Brookville*	0	2½
Clay shale, dark to black	*Brookville*	0	3½
Coal, shaly	*Brookville*	0	6
Clay, dark gray, plastic		0	11
Clay, light, siliceous, plastic		4	3
Sandstone, white, clay-bonded, thin-bedded		3	2
Covered		3	0

Just north of the village of Baltic in Sec. 25, the Putnam Hill member crops out a few feet above the valley bottom of Brush Run and its tributaries at an elevation ranging from 1,040 to 1,050 feet. In Sec. 25 the limestone is thinner, darker, and more ferruginous and irregular than usual.

The foregoing illustrates the fact that the Putnam Hill limestone in much of southeastern Clark Township does not have its typical appearance, and the member is difficult to follow as a key horizon. The ferruginous character of the clay shale overlying the Putnam Hill member, as well as the abundance of iron concretions which the shale contains, is undoubtedly related to the atypical character of the limestone in this part of Holmes County. At the majority of the outcrops of this shale overlying the Putnam Hill limestone throughout Holmes County many iron concretions are present and the shale is ferruginous. The conditions favoring the deposition of iron in the overlying shale seem to have set in somewhat earlier in time in this corner of Clark Township than throughout most of the county. A comparison of the fauna of the typical and of the aberrant forms of this limestone would be interesting and instructive.

The conditions of sedimentation giving rise to the change in character of the Putnam Hill limestone were not at all widespread, as shown by the outcrops in the northeastern corner of Crawford Township, Coshocton County, which adjoins Clark Township on the south, and in the extreme southeastern corner of Clark Township. Outcrops along roads and in ravines in this corner of Crawford Township show the Putnam Hill limestone to be 2 feet or more in thickness and to be lighter and less ferruginous; in other words, more typical than in the southeastern part of Clark Township.

In the southeastern corner of Clark Township the change in the Putnam Hill limestone from the irregular facies to the normal facies is very abrupt. In south central Sec. 17 the limestone is thin, dark, and very ferruginous. However, about one-half mile south, in SW¼NE¼ Sec. 24 the member presents its usual appearance, as shown by the following section exposed in a run and up a hill to an old mine:

		Ft.	In.
Shale, carbonaceous; increasingly siliceous toward top		20	0
Coal, bony	*Lower Kittanning*	0	6
Coal, mined		2	6
Clay and covered		5	0
Shale, and covered		40	4
Limestone, gray, hard, dense, platy, *Putnam Hill*, altitude 1,100 feet		5	8

At this outcrop the Putnam Hill is thicker than at any other exposure observed in southeastern Holmes County. It is particularly noteworthy inasmuch as it is so close to the irregular area which has been described above. This thickness does not continue to the south into Bucks Township, Tuscarawas County. Observations to the east in Auburn Township, Tuscarawas County, indicate that the vertical extent of the bed, in the part of Auburn Township adjoining Holmes County, is also not as great as in the outcrop in Sec. 24.

Mechanic Township.—The Putnam Hill limestone is found generally near the tops of the hills and ridges, in the eastern, northern, and northwestern parts of Mechanic Township. The central and southern parts of the township have been reduced by erosion to such a low level that the Putnam Hill limestone has been removed.

In the northeastern corner of Mechanic Township in Sec. 1 the limestone underlies the high ridge in the northern and northwestern parts of the section at an elevation of about 1,130 feet. Here the limestone is gray, dense, fossiliferous, and weathered to a platy outcrop. The full thickness is not exposed at any place in this section but it is believed to be 3 feet or more.

The limestone underlies the northern and eastern parts and two or three small hills in the central part of Sec. 2. At the road fork at the line between Sec. 2 and Sec. 9 the limestone is the typical gray, dense, fossiliferous rock (125-110, Appendix). The limestone caps the hill one-fourth mile southeast of Deetz School, in NE¼SW¼ Sec. 2, where the thickness is 3 feet 7 inches and the elevation is 1,150 feet (126-112).

Between Grade and Saltillo the Putnam Hill limestone crops out along the sides of the hills at elevations ranging from 1,120 to 1,100 feet. The limestone caps the ridge which trends north-south about one-fourth mile west of Webster Hall School. Where the east-west road crosses this ridge one-third mile southwest of the school, the limestone is 3 feet in thickness (130-38).

In the northwestern corner of Mechanic Township the Putnam Hill member crops out boldly along the cut of the old Millersburg-Coshocton road on Sand Run Hill in NE¼ Sec. 1 at an elevation of approximately 1,100 feet, where the unit is 3 feet thick (133-36).

In central E½ Sec. 2 the Putnam Hill limestone is exposed along the road at an elevation of approximately 1,075 feet, where a thickness of 4 feet is present (134-34). In secs. 9 and 10 the elevation is such that large parts of these two sections are underlain by the limestone, at elevations of from 1,085 to 1,090 feet. The limestone is present in much of Sec. 19, but satisfactory outcrops were not seen. In NW¼NE¼ Sec. 20 the limestone still remains in a very small area at the top of a hill which is crossed by the Millersburg-Coshocton state road. The following section is exposed:

	Ft.	In.
Shale, clayey to siliceous, with some iron stains	13	0
Limestone, weathered, near top of hill, *Putnam Hill*, altitude 1,065 feet	3	0
Coal, good } *Brookville*	0	11
Coal, shaly } *Brookville*	0	3
Coal, good } *Brookville*	0	4
Clay, white, plastic, good	6	6
Sandstone, white	5	0
Sandstone, thin-bedded to shaly; somewhat cross-bedded	29	0
Covered, and sandstone	10	0

As mentioned before, the surface of the central and south central parts of Mechanic Township has been lowered below the Putnam Hill horizon. Two small outliers remain at the tops of two knobs, on one of which is located the abandoned Methodist church, three-fourths mile east of SE¼ Sec. 11. A record of the beds cropping out along the road follows:

	Ft.	In.
Shale, clay, slightly ferruginous	10	0
Limestone, *Putnam Hill*, altitude 1,080 feet	3	4
Coal, weathered, *Brookville*	1	7
Clay, siliceous, plastic, good	5	6
Shale, sandy, white, clay-bonded	5	0
Shale, sandy, yellow, a few iron nodules	20	0

In Sec. 11 of eastern Mechanic Township the Putnam Hill limestone is apparently absent, having been replaced by calcareous and ferruginous shale. Several satisfactory outcrops of the beds which occur above and below the Putnam Hill member are exposed along the road up the hill east of Becks Mills in the central and central eastern parts of Sec. 11. The Brookville coal which immediately underlies the limestone is identified, but at no place does the Putnam Hill limestone itself appear on the outcrops along this road. It was not seen in Sec. 20 and is thought to be absent through lack of deposition. These conditions exist also to a certain extent, as noted before, in Sec. 15, Clark Township, which adjoins the part of Mechanic Township under discussion. The Putnam Hill throughout Holmes County is generally a steady member and can be found without much difficulty, therefore its absence in southeastern Mechanic Township is especially noteworthy.

Killbuck Township.—The Putnam Hill limestone has been removed by erosion from a large part of Killbuck Township and the limestone remains only at the tops of some of the higher hills and ridges. Less than a square mile of the bed remains in Killbuck Township north of Shrimplin and Killbuck creeks. Two small outliers are found in the southwestern part of the township. The remainder of this limestone is found east of Killbuck Creek in the eastern portion and to a small extent in the southeastern portion of the township.

North and west of Killbuck Valley in N½ Sec. 4 and NE¼ Sec. 5, the limestone occurs at elevations of 1,140 to 1,160 feet. No clear outcrops of the limestone were observed in either secs. 4 or 5, but less than one-half mile to the north of Sec. 4, in Hardy Township, the limestone has a thickness of about 6 feet (55-401, 56-295, Appendix).

Two high knobs in the southwestern corner of Killbuck Township remain at sufficient height to retain the limestone near their tops. In S½ Sec. 23 near the top of the ridge which rises to a little more than 1,220 feet, the limestone crops out at an elevation of approximately 1,200 feet. It has been quarried in a small way near the road (144-345A). The Putnam Hill limestone, with an apparent thickness less than 2 feet, is exposed at an elevation of approximately 1,190 feet where it underlies the top of the high knob in NW¼NE¼ Sec. 22. (145-368).

The largest area of the Putnam Hill limestone in Killbuck Township is found in the eastern part. This member underlies a large part of Sec. 13 at an elevation of approximately 1,100 feet with a thickness of about 3 feet (150-69). The bed crops out along the road just west of the road fork, in NW¼ Sec. 14 (147-273), where the ledge crossing the road is about 3 feet in thickness.

In NE¼SE¼ Sec. 18 the rock has been quarried for agricultural purposes, the member having a thickness of 3 feet. (152-75). In Sec. 23 several small knobs rising to heights of about 1,100 feet have retained the limestone almost at their summits. In NE¼SW¼ Sec. 23 the Putnam Hill is 3 feet thick (154-77).

Richland Township.—Some of the higher land in Holmes County occurs in Richland Township and the beds which might normally be expected to have been long since eroded are retained under small areas near the tops of these high hills and ridges. Outcrops of Putnam Hill limestone are found in the central southern part of the township, in secs. 12, 18, 19, 22, 23, and in the southeastern corner of the township in Sec. 24. In the central eastern part of Richland Township in secs. 11 and 15, where the height of the hills is sufficient to have retained the Putnam Hill stratum, the horizon of the Putnam Hill limestone is occupied by the upper part of the massive Homewood sandstone, which in turn is overlain by the coarse sandstone which replaces the Lower Kittanning strata.

In SE¼SE¼ Sec. 12, two feet 6 inches of Putnam Hill limestone crops out along the road at an elevation of about 1,260 feet. In central

Sec. 19 the bed has a thickness of almost 5 feet where it is exposed at the tops of several knobs at an elevation of approximately 1,250 feet. In the central and E½ Sec. 13 the Putnam Hill limestone is due but no indications of it could be found, although the underlying Brookville coal is tentatively identified. (164-364). In SE¼ Sec. 18 the limestone crops out along the road at an elevation of approximately 1,260 feet, where the following measurements were secured:

	Ft.	In.
Shale, clay-like, calcareous, with some ore balls	9	8
Limestone, soft gray, dense, hard, fossiliferous; (may be thicker), *Putnam Hill*	3	4
Clay and covered	5	0
Shale, and covered; loose pieces black flint prominent but not seen in place	77	0

The high knob which rises to a height of a little more than 1,300 feet in SE¼ Sec. 23 and SW¼ Sec. 22 is underlain by the limestone. As nearly as can be determined this stratum crops out at an elevation of 1,250 feet. The bed is not in place around the sides of this high knob but many loose blocks of the limestone are scattered over the sides of the hill. Along the road in SE¼ Sec. 23 the bed is thought to be very nearly in place. The limestone here seems to be quite typical. It has the common gray color, weathering to platy pieces on the outcrop, and containing a moderate number of fossils. The section follows:

	Ft.	In.
Limestone, loose blocks, *Putnam Hill*	0	6
Coal, very shaly, to coaly shale, *Brookville*	2	5
Clay, light to gray, siliceous, plastic	4	9
Sandstone, light, clay-bonded, shaly	8	0

In the southeastern corner of the township, the limestone crops out in the bank of the road which follows the Holmes-Coshocton county line along the southern boundary of Sec. 24 at an elevation of approximately 1,230 feet. The full thickness of the bed could not be determined because it is very close to the top of the hill. Measurements at the road fork are as follows:

	Ft.	In.
Shale, clay, with small ore balls	5	0
Limestone, gray, loose weathered pieces, *Putnam Hill*	1	2
Clay, light, plastic, *Brookville*	4	0

ECONOMIC VALUE

The Putnam Hill limestone is an important mineral resource of Holmes County and has been quarried in almost every township. It is widely distributed, as shown on the geologic map of the county. Its average thickness is 3 feet 4½ inches, but considerable areas having a thickness of 5 to 6 feet are available. The limestone is bluish gray, finely crystalline, and compact. In fresh exposures it consists of a single bed, but at weathered exposures it is separated into irregular plates, 2 to 6 inches in thickness.

The stone has been used in small amounts for road stone and concrete aggregate, for which uses it is satisfactory. Large amounts have been used for agricultural purposes. In former years it was calcined for agricultural lime in temporary kilns in open fields.[1] Although an occasional kiln is still burned for lime, the application of finely ground limestone to fields has become more and more common.

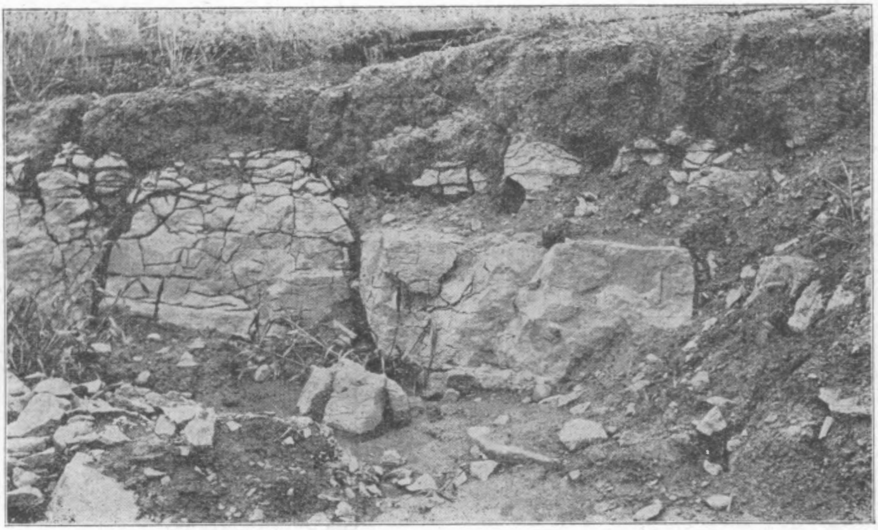
As shown by the accompanying analyses, the Putnam Hill is a true limestone, having a high proportion of calcium carbonate. Magnesium carbonate is small in amount, averaging about 2 percent. Silica and clay are low. In addition to use as road metal, concrete aggregate, and ground limestone, the Putnam Hill limestone is well adapted to manufacture of lime and especially of cement. An abundant supply of shale for use with the limestone in cement manufacture is available immediately over the Putnam Hill at most localities.

ANALYSES OF PUTNAM HILL LIMESTONE FROM HOLMES COUNTY

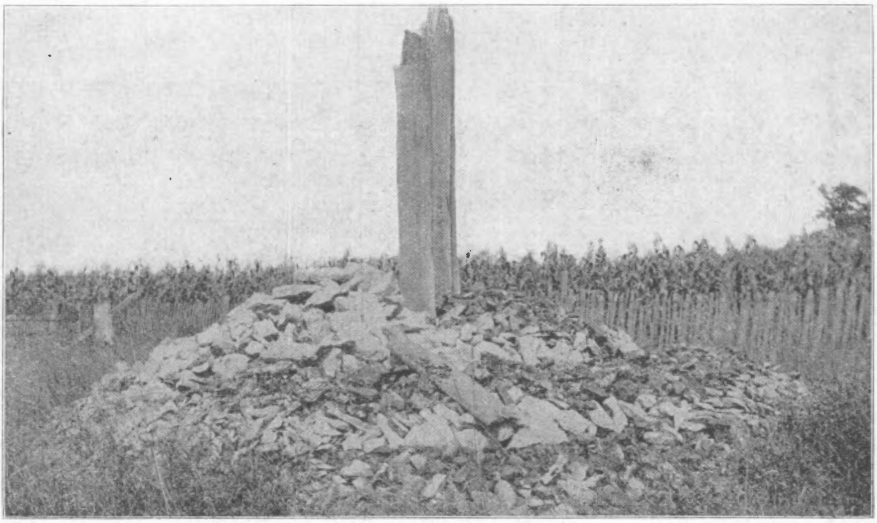
	A	B	C	D
Silica, SiO_2	2.17	2.44	2.59	1.82
Alumina, Al_2O_3	0.68	0.88	0.83	0.88
Ferric oxide, Fe_2O_3	0.02	0.02	0.03	0.08
Ferrous oxide, FeO	0.74	0.70	0.83	0.74
Pyrite, FeS_2	0.02	0.11	0.09	0.14
Magnesium oxide, MgO	0.98	1.02	0.95	0.95
Calcium oxide, CaO	52.21	51.80	51.81	52.21
Strontium oxide, SrO	<0.01	0.01	<0.01	<0.01
Barium oxide, BaO	<0.01	0.01	<0.01	<0.01
Sodium oxide, Na_2O	<0.01	0.03	0.02	0.02
Potassium oxide, K_2O	0.02	0.10	0.04	0.09
Water, hydroscopic, H_2O-	0.20	0.22	0.12	0.15
Water, combined, H_2O+	0.22	0.25	0.23	0.23
Carbon dioxide, CO_2	42.47	41.98	42.08	42.35
Titanic oxide, TiO_2	0.04	0.06	0.05	0.06
Phosphorus pentoxide, P_2O_5	0.10	0.21	0.14	0.16
Sulphur trioxide, SO_3	0.04	0.05	0.03	0.06
Manganous oxide, MnO	0.18	0.07	0.09	0.14
Carbon, organic, C	0.02	0.09	0.10	0.05
Hydrogen, organic, H	...	...	0.01	...
Total	100.11	100.03	100.04	100.13

[1] A typical kiln is about 20 by 40 feet in ground plan. The base is made of an 8- to 12-inch layer of old fence rails or similar timbers. Straw is placed on the wood to prevent the coal from falling through, wheat straw being preferred because oat straw becomes too damp. A layer of run-of-mine coal, about 2 tons, is then spread evenly, upon which pieces of limestone are laid on edge to allow for draft. A layer of 2 tons of nut coal is then placed upon the limestone. Succeeding layers of coal and limestone are then built, the total number varying from six to eight. The top is made of fine limestone covered by slack and nut coal to a thickness of 4 or 5 inches. The sloping sides are covered with about 1 foot of soil, preferably with an outer covering of sod. In building the kiln, two stacks about 6 by 6 feet are left. Fire is started with corncobs and oil, and after a few minutes the stacks filled first with coal and then limestone. Such a kiln burns for from four to six days. About 1,000 bushels of limestone are required to build a kiln and from it are produced about 2,000 bushels of slaked lime.

PLATE V



A.—View of Putnam Hill limestone showing character of weathered outcrop. (From Geol. Survey Ohio Bull. 24, 1921.)



B.—Preparing a limestone kiln for burning. Note alternate layers of coal and limestone. (From Geol. Survey Ohio Bull. 24, 1921.)

A.—Samples collected in May, 1941, by R. E. Lamborn. Downs Schaaf, analyst. No. GSO 336. 6 feet of bluish-gray Putnam Hill limestone in quarry of E. Mullet, NE¼SW¼ Sec. 3, Salt Creek Township, 1½ miles west of Mt. Hope.

B.—No. GSO 339. 5 feet bluish-gray Putnam Hill limestone in quarry of Andy Swartzentruber, E central Sec. 6, Salt Creek Township, 3 miles east of Holmesville.

C.—No. GSO 330. 5 feet 2 inches to 5 feet 11 inches of dark bluish Putnam Hill limestone in quarry of Nashville Limestone Quarries, in Knox Township, one-fourth mile south of Stones School, 1½ miles southeast of Nashville, and 1 mile west of Monroe Township.

D.—No. GSO 337. 5 feet of hard, bluish limestone in quarry of Kazer Brothers, NE¼ Sec. 17, Hardy Township, 3 miles east of Millersburg.

SHALE OVERLYING THE PUTNAM HILL LIMESTONE

Over large parts of Holmes County the interval from the Putnam Hill limestone to the Lower Kittanning clay and coal is made up of shale. The common thickness is from 25 to 50 feet but the maximum and minimum may vary considerably from these figures. At most places the shale in the lower part of the interval is very fine-grained; almost, if not quite, a clay shale. This clay shale grades upward into siliceous shale and thence to sandy shale. At places the upper part of the interval is thin-bedded sandstone and locally true sandstone appears. Stratigraphically these shales are a combination of the Clarion shale and the Lower Kittanning shale.[1] These cannot be separated in Holmes County because the Vanport limestone and Clarion coal which lie between the two shales in some parts of Ohio are generally wanting; in this county the two shales were deposited continuously as one member.

At most exposures the lower part of the shale is somewhat calcareous and somewhat ferruginous. The iron content decreases upward. Iron concretions are found commonly in the lower few feet of the shale above the Putnam Hill limestone. These concretions were originally iron carbonate, but almost everywhere on the outcrop they are weathered to limonite, and in some places the surrounding shale changed to a rusty color. Generally, however, the shales have a somewhat greenish-gray tint—a very light greenish tone. This greenish tone is so typical of the shales above the limestone that at some places where the underlying limestone is not exposed the approximate horizon is marked by the greenish clay shale which appears at the surface. In wet weather these greenish clay shales are very plastic and sticky.

"Ironstone" concretions, where present, are rarely arranged in bands or layers. At a very few exposures a layer of ore from 1 to 6 inches thick occurs but ordinarily the iron is concentrated in nodules. Many sections which show the thickness and character of the shale are given in the discussion of the Putnam Hill limestone and in the Appendix.

These shales in SE¼ Sec. 25, Clark Township, have been utilized to some extent by the General Clay Products Company of Baltic for making

[1] Lamborn, R. E., Shales and Surface Clays of Ohio: Geol. Survey Ohio Bull. 39, pp. 119, 138, 1938.

drain tile and building block. Some of the shale used at this plant comes from the Lower Kittanning coal but most of it is from above the Middle Kittanning coal. The shales between the Putnam Hill limestone and the Lower Kittanning coal here are thinner than those above the Middle Kittanning coal, but in 1929 were used extensively. The character and properties of the shale are described as follows by Lamborn:[1]

"About one-half mile north of Baltic in the southern part of Sec. 25, Clark Township, Holmes. County, the shale lying close below the Lower Kittanning clay is worked by the General Clay Products Company for building block and drain tile. The capacity of the plant is about 38,000 feet of 3-inch tile per day. A section of the exposures in the pit is given below:

		Ft.	In.
"Shale, gray, sandy		26	0
Shale, bluish-gray, with ore nodules		8	6
Shale, black, carbonaceous		2	0
Coal, weathered, *Middle Kittanning*		3	0
Clay, ferruginous, siliceous		5	0
Clay and covered		14	9
Coal, *Lower Kittanning,* not entire thickness		1	0
Covered interval		9	6
Shale, greenish-gray, sandy	*Lower Kittanning*	19	3
Shale, bluish-gray, with a few thin layers of iron carbonate	*Lower Kittanning*	4	0

"Both the Middle Kittanning clay and the shale above the Middle Kittanning coal have been utilized at this plant, but in 1929 the Lower Kittanning shale was used exclusively. A sample of Lower Kittanning shale from this pit was cut on August 6, 1929. It was submitted for testing with the following results:

Sample No. 31

"Tests of Lower Kittanning shale from pit of the General Clay Products Company near Baltic, Holmes County. Downs Schaaf, analyst.

Chemical analysis	
Water, hydroscopic, H_2O-	0.92
Water, combined, H_2O+	5.60
Silica, SiO_2	59.82
Alumina, Al_2O_3	19.29
Titanic oxide, TiO_2	1.27
Phosphorus pentoxide P_3O_5	0.16
Ferric oxide, Fe_2O_3	4.92
Ferrous oxide, FeO	1.74
Lime, CaO	0.56
Magnesia, MgO	1.80
Sodium oxide, Na_2O	0.39
Potassium oxide, K_2O	2.90
Manganese oxide, MnO	0.07
Sulphur trioxide, SO_3	0.19
Carbon dioxide, CO_2	0.29
Carbon, organic, C	0.22

Oxide ratio

$$\left.\begin{array}{ll} K_2O & .150 \\ Na_2O & .020 \\ CaO & .029 \\ MgO & .093 \\ FeO & .320 \\ MnO & .004 \end{array}\right\} Al_2O_3\ 1.00 \left\{\begin{array}{ll} SiO_2 & 3.101 \\ TiO_2 & 0.065 \\ P_2O_5 & 0.009 \end{array}\right.$$

RO ...... .616

Physical properties, determined by Chester R. Austin

Properties in green state

[1] *Ibid.*, p. 142-143.

Workability: This material has fair plasticity. A good column is extruded from the die.

Time of slaking: 11.76 minutes

Water of plasticity: 20.57 per cent

Dry shrinkage:

Volume: 10.90 per cent
Linear: 3.51 per cent

Drying behavior: This material dries satisfactorily with ordinary care.

Dry modulus of rupture: 317 pounds per square inch.

Firing behavior

Cone	Apparent porosity per cent	Volume shrinkage per cent	Calculated linear shrinkage per cent	Absorption per cent	Bulk specific gravity	Apparent specific gravity
06	24.68	12.47	4.0	12.24	2.01	2.68
04	17.20	18.63	5.9	8.00	2.15	2.60
02	14.81	21.58	6.7	6.73	2.24	2.63
1	12.29	23.83	7.4	5.46	2.31	2.64
3	9.96	25.40	7.8	4.19	2.37	2.64
5	6.14	25.63	7.9	2.58	2.38	2.53
7	5.10	25.38	7.8	2.20	2.33	2.45

Fired modulus of rupture:

Cone 02, 2,513 pounds per square inch
Cone 5, 3,505 pounds per square inch

Fired specific impact strength:

Cone 03, 1.08 centimeter kilograms per square centimeter
Cone 4, 1.24 centimeter kilograms per square centimeter

Fired crushing strength: Cone 5, 16,449 pounds per square inch

Best firing range: Cone 06 to cone 5

Overfiring temperature: Cone 7

Pyrometric cone equivalent: Cone 13-14.

Scumming: Scum occurs on all trials fired to cone 2 and lower but scum is not apparent on trials fired above cone 2. One pound of $BaCO_3$ per ton of material is necessary to prevent scumming.

Salt glazing: The salt glaze produced at 2,050° F. has a dark brown color. The glaze produced at 2,100° F. is a yellowish green and pinkish gray mottle on a reddish brown background. When $BaCO_3$ is added the glaze produced at 2,100° F. has a chocolate brown color.

Utilization: This shale is being used for the production of drain tile. It can be used also for face brick, common brick, and possibly for hollow tile. The fired material develops a good red color at cone 02."

The thickness of the shale under discussion, apparently suited for ceramic purposes, seems to be greatest in Walnut Creek Township. Near the road forks in SW¼NW¼ Sec. 16 of this township, 47 feet of fine-grained to siliceous shale overlain by 9 feet of Lower Kittanning clay is present (89-132).

The sedimentary succession of these shales seems to indicate that uninterrupted deposition went on from the depositing of the Putnam Hill limestone to the laying down of the overlying Lower Kittanning clay and coal. Marine conditions are indicated for the deposition of the Putnam Hill limestone. The deposition of the limestone was halted rather abruptly and shales, somewhat calcareous, were deposited. The change in conditions must have been very rapid, and possibly lagoon-like conditions gave rise to the deposition of the iron in the shales. The lower part of the shale bed is very fine but grades upward into coarser and coarser materials. Except in very restricted areas, where coarse sandstone cuts out the Lower Kittanning members and rests upon the shale under discussion, there is no unconformity between the thin-bedded sandstone which is locally found in the upper part of the interval and the underlying shale.

In central eastern and southeastern Knox Township, in western Monroe Township, and in northeastern Richland Township, the Putnam Hill limestone and the shales above have been replaced by coarse sandstone, which has also replaced the Lower Kittanning members. It is believed that in this area the limestone was deposited, followed by shale and then by Lower Kittanning clay and coal. Later, erosion extended to and below the Putnam Hill horizon. To the east and south of this area where the limestone has been cut out, outcrops of the Putnam Hill limestone show no indication of thinning or change of character which would be expected in approaching an area in which the limestone had never been deposited. In northeastern Knox Township, in the area where Putnam Hill limestone is due but not usually found, several outcrops of the Putnam Hill are present in an area which was a hilltop in post-Putnam Hill time that escaped the depth of erosion of the region surrounding. Significantly, the limestone in this locality, although not reduced in thickness, is somewhat atypical. Perhaps it was altered by groundwater action in early Allegheny time.

VANPORT LIMESTONE

In some parts of Ohio the Vanport limestone is of large importance in the Allegheny section, but this member is of very negligible importance in Holmes County, and indeed it was seen in only two localities. The Vanport limestone and the associated Clarion coal are well developed south of Holmes County in Coshocton County. Nine miles south of the Holmes-Coshocton county line, the beds exposed up the road to the northwest from the head of Flint Run, 1½ miles south-southeast of Mohawk village, Jefferson Township, Coshocton County, show the thickness, character, and arrangement of the Vanport, the Clarion, and the associated members as follows:

		Ft.	In.
Flint, cream-colored, hard, dense, scattered pieces.	*Vanport*		
Limestone, blue gray, argillaceous, sparingly fossiliferous, somewhat shaly	*Vanport*	4	0
Shale, blue gray, calcareous	*Vanport*	1	8
Coal, fair, weathered	*Clarion*	1	3
Clay shale, light	*Clarion*	0	¾
Coal, fair, weathered	*Clarion*	1	5
Clay, light, siliceous, plastic		3	6
Sandstone, irregular, thin-bedded, clay-bonded		11	0
Clay shale, slightly ferruginous		36	10
Limestone, gray to grayish brown, platy, fossiliferous, weathered, *Putnam Hill*, altitude 1,050 feet		6	6
Covered		17	11
Flint, light	*Upper Mercer*	2	1
Flint, black, hard, fossiliferous	*Upper Mercer*	11	8
Limestone, dark blue, fossiliferous, black flint mixed through	*Upper Mercer*	5	6
Clay shale		0	8
Coal, weathered	*Bedford*	0	4
Clay shale, light	*Bedford*	0	1
Coal, canneloid, shaly	*Bedford*	0	11
Clay, light, plastic, slightly siliceous		2	6

The above section illustrates the Clarion coal and the Vanport limestone 9 miles south of the southwestern portion of Holmes County. About 10 miles south of the southeastern part of Holmes County and about 18 miles east of the rock section above, the Vanport limestone has the following characteristics, as shown in a ravine from the Lafayette-White Eyes township line, up to the road fork three-eighths mile west-southwest of Bowman School, in the southeastern corner of White Eyes Township, Coshocton County:

		Ft.	In.
Coal blossom, *Middle Kittanning*		1	0
Shale and covered		26	4
Coal, fair, weathered, *Lower Kittanning*		2	6
Covered		16	6
Flint, very pure, cream-colored, *Vanport*, altitude 976 feet		9	8
Shale, ferruginous		15	4
Limestone, gray, platy, *Putnam Hill*		1	4
Clay shale		0	2
Coal	*Brookville*	0	5
Clay shale	*Brookville*	0	2
Coal	*Brookville*	0	5
Clay and covered		6	0
Ganister, white, shaly		21	6
Sandstone, shaly, irregular		16	1
Ore, gray tan, dense, *Upper Mercer*		0	7
Shale, gray, clay-like		0	10

		Ft.	In.
Shale, fissile	Bedford	1	0
Shale, black, hard, bone	Bedford	1	2
Shale, carbonaceous	Bedford	1	2
Sandstone, white, shaly		18	2
Coal, shaly, canneloid, *Upper Mercer*		2	2
Clay, impure, and covered		3	0
Shale, white, sandy		18	0
Limestone, blue, fossiliferous, incipiently shaly, *Lower Mercer*		3	0
Clay and covered		3	0
Sandstone, mostly 1-inch to 2-inch beds		15	0

In Holmes County, an outcrop of material which may be Vanport was seen in the northwestern part of Clark Township in SW¼NW¼ Sec. 4, one-half mile north of Charm, where a limestone crosses the road in a definite ledge. The measurements at this locality and the relation to the Putnam Hill limestone are as follows:

		Ft.	In.
Coal smut, *Lower Kittanning*		0	1
Covered		8	0
Limestone, greenish gray, slightly nodular, incipiently flinty, very dense, *Vanport?*		1	0
Clay shale, greenish		5	0
Clay shale, with iron concretions		12	0
Limestone, bluish gray, hard, *Putnam Hill,* altitude 1,150 feet		1	0
Clay shale		0	2½
Coal	Brookville	0	6
Shale, coaly	Brookville	0	5
Clay, light, siliceous		5	0
Clay, white, very sandy		3	0

In the northeastern corner of Mechanic Township, 1½ miles west of the locality in Clark Township, a limestone which may be Vanport crops out along a road in NW¼NE¼ Sec. 1. The limestone, grayish green, porous, and ferruginous, is 1 foot 6 inches in thickness and overlies 3 feet of gray-green shale. The limestone lies 27 feet above the Putnam Hill and 24 feet 6 inches below the Lower Kittanning clay, as shown in stratigraphic section 122-78, Appendix.

In a field east of the road in NW¼SW¼SW¼ Sec. 23, Richland Township, a few pieces of hard, translucent, dense, straw to light gray flint resembling Vanport, are scattered over the surface at an elevation of approximately 1,280 feet, about 20 feet above the poorly exposed Putnam Hill limestone. The bed from which they came could not be located; probably it has been removed by erosion, leaving a few pieces of resistant flint behind.

LOWER KITTANNING COAL AND CLAY

STRATIGRAPHY AND EXTENT

"The Lower Kittanning coal was first described in 1858 by H. D. Rogers of the First Pennsylvania Survey as the Kittanning coal, from exposures near Kittanning in Armstrong County. It is one of the best-known members of the Allegheny formation. The stratum is steady and widely distributed. It is present in large areas in western Pennsylvania, western Maryland, northern West Virginia, eastern and southern Ohio, and eastern Kentucky. It enters Ohio from Pennsylvania in Columbiana and Mahoning counties and passes into Kentucky in Lawrence and Scioto counties on the Ohio River. Also the bed is found at the surface to some extent in Jefferson, Stark, Carroll, Tuscarawas, Wayne, Holmes, Coshocton, Guernsey, Muskingum, Licking, Perry, Hocking, Athens, Vinton, Gallia, and Jackson counties. As a source of fuel the member is most valuable in Columbiana, Tuscarawas, Jackson, and Lawrence counties where its thickness is sufficient for drift mining in a large way and the quality of the coal is near the standard for this State. This coal is mined in a small way for local needs throughout most of the remainder of the field. In importance the Lower Kittanning coal ranks below the Pittsburgh, Middle Kittanning, and Upper Freeport but above the Clarion, Brookville, Sharon, Quakertown, and Meigs Creek coals. When, however, both coal and clay are considered, the economic value of the strata on this horizon far surpasses any other in the coal formations of Ohio."[1]

The Lower Kittanning, or No. 5[2] coal, is the most important coal bed in Holmes County. It is now being, or has been, mined in all the townships of the county except Prairie, Ripley, and Washington. Its extensive outcrop is shown on the geologic map of Holmes County but its outcrop is omitted from the map or shown by a dashed line where the coal is continuously thin or where its existence is questionable or unknown. Although it is the most important coal bed in Holmes County, its thickness and steadiness are not as uniform as in counties to the east and southeast. The member is generally present where due, unless replaced by sandstone, although at places it may be reduced to a mere smut streak. It may show great variation in thickness over short distances. It is replaced by sandstone in several localities.

The average thickness of the coal, calculated from 79 measurements throughout the county, is 2 feet 1 inch. The greatest thickness observed is 4 feet 9 inches; and the least 1 inch. A greater thickness has been reported from near Trail in Walnut Creek Township but was not seen. The average of 69 measurements from the base of the Lower Kittanning coal to the base of the Putnam Hill limestone is 39 feet 8 inches. The longest interval from the base of the Lower Kittanning coal to the base of the Putnam Hill limestone is 71 feet and the smallest interval 16 feet. The average distance

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[1] Stout, Wilber, Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 291, 1927.

[2] In many parts of Holmes County the Lower Kittanning coal is called the 'Number 6,' following the earlier erroneous identification of the coal beds above the Putnam Hill limestone by M. C. Read in 1878, Report of the Geological Survey of Ohio, Vol. 3, Pt. I, pp. 543, 555, 1878. The error was suspected, and the correct identification of these upper coals was surmised but not insisted upon in 1884 by A. A. Wright, Report of the Geological Survey of Ohio, Vol. 5, pp. 832, 841, 1884.

from the base of the Lower Kittanning coal to the base of the Middle Kittanning coal is 43 feet 5 inches, computed from 33 measurements. The longest interval from the Lower Kittanning coal to the Middle Kittanning coal is 80 feet 5 inches; and the shortest 18 feet.

The coal is bright, banded, blocky, bituminous coal. In a part of Killbuck Township and rarely in other parts of the county, streaks of cannel coal are interbedded. The bed commonly has several carbonaceous shale partings but these are not as continuous or regular as the persistent partings so characteristic of the Bedford and Brookville coals.

The roof of the Lower Kittanning coal is commonly the Hamden fossiliferous shale of marine origin. In many parts of the county, massive sandstone overlies the coal replacing the Hamden shale, and at places, the coal and even the underlying clay.

The Lower Kittanning clay, is "without question the most valuable and persistent clay stratum in Ohio," [1] Indeed, it has been called by Stout the "greatest clay bed in America." The bed is utilized to some extent in nearly every county of Ohio in which it is present. Lower Kittanning clay in western Pennsylvania, western Maryland, northern West Virginia, and in eastern Kentucky is used extensively for ceramic purposes. It is "especially well fitted for the production of sewer pipe, face brick, stoneware, yellow ware, fire proofing, and refractory ware."[2]

In Holmes County the Lower Kittanning clay is probably not as important as the Brookville clay. In this county the clay underlying the Lower Kittanning coal is everywhere, with but minor exceptions, present beneath its coal, although at a few localities it is thin and impure. In some places where sandstone has cut out the coal, all or part of the underlying clay is preserved, and the stratigraphic position of the Lower Kittanning horizon may thus be recognized. In Holmes County there is little or no indication of the double structure of the clay as shown elsewhere in the State, especially in southern Ohio, as described by Stout.[3]

The thickness of the Lower Kittanning clay in Holmes County is, on the average, 5 feet 4 inches. The greatest thickness observed is 10 feet 6 inches. As the clay in mines is never so well exposed as the overlying coal, it is possible that at some place in the county a greater thickness than this may exist. A maximum thickness of 12 feet in this county is reported by Stout.[4]

In Holmes County the clay is everywhere of the plastic variety. At a few places in Ohio a small amount of flint clay is associated with the plastic clay at this horizon,[5] but no flint clay at the Lower Kittanning

[1] Stout, W., *op. cit.*, Bull. 31, p. 276.
[2] *Ibid.*, p. 276.
[3] Stout, W., and others, Coal Formation Clays of Ohio: Geol. Survey Ohio Bull. 26, pp. 269-272, 1923.
[4] *Ibid.*, p. 322.
[5] *Ibid.*, p. 272.

horizon was seen in Holmes County. The clay seems to be fairly uniform in grade, and though no analyses from Holmes County are at hand, the quality, at least in places, probably approaches the average. At many places this clay is siliceous and the lower part may be sandy. At some exposures a ganister, or white, clay-bonded sandstone underlies the clay. Ganister, in Holmes County, however, is not nearly so universally present underneath the Lower Kittanning clay as it is beneath the Brookville clay.

This clay is not as yet used for ceramic purposes in Holmes County. Its stratigraphy and extent are discussed along with that of the overlying coal, township by township.

Paint Township.—The Lower Kittanning members crop out in the northeastern corner, in the central northern part, and along the sides of the high Winesburg Ridge in the southern part of Paint Township. The Lower Kittanning coal and clay are due in the northwestern corner of the township but owing to the cover of glacial drift no outcrops are present.

The coal was once mined in a small way in NW¼NE¼ Sec. 36 in northeastern Paint Township (1-228, Appendix), but the mine has fallen in and no measurements can be secured at this place. The coal and clay underlie the top of the hill in SW Sec. 26, where in gullies in a field 5 feet of clay and a few inches of shaly coal are exposed (2-229). In NW¼ Sec. 33 and NE¼ Sec. 32 the beds are due but the bedrock is thickly covered with glacial drift. Parts of secs. 30 and 31, in the northwest corner of the township adjoining Salt Creek Township, are high enough to carry the Lower Kittanning members but the covering of drift conceals the bedrock. A few inches of carbonaceous shale at the crossroads at the boundary between SE¼ Sec. 29 and NE¼ Sec. 32 probably represents the Lower Kittanning coal horizon, at an elevation of 1,275 feet.

In the southwest corner of Paint Township the coal attains a thickness of 2 feet 9 inches and has been mined on the farm of Samuel Troyer by J. W. Dowalter and Alfred Flinter, 100 yards north of Walnut Creek Township, and three-fourths mile east of Salt Creek Township, southwest of Easley School (5-227). About a mile northeast the coal and clay crop out along the state road on Seven Lick Hill, one-fourth mile northeast of Easley School. The coal has a thickness of 3 feet 6 inches, and was formerly mined near this locality (4-207).

The unsteady character of the Lower Kittanning coal is shown by the fact that along the north-south road, 1 mile east of Easley School and three-fourths mile north of the Paint-Walnut Creek township line, the thickness of the coal is only 6 inches (6-205).

One mile west of Winesburg the coal was once mined from an opening just north of the road. This opening has now fallen in and detailed measurements are impossible (8-206.)

The Lower Kittanning members do not crop out between Winesburg and the Tuscarawas County line, a distance of 2 miles. However, just across the county line in Tuscarawas County, 2½ miles east-northeast of Winesburg, a few inches of Lower Kittanning coal is partially exposed just east of where a lane enters the ridge road from Winesburg to Beach City. Its position is 50 feet above the Putnam Hill limestone and 23 feet 8 inches below the Middle Kittanning coal. One-half mile east of Holmes County and 1 mile north of Indian Trail Creek, in Wayne Township, Tuscarawas County, the Lower Kittanning member has fair thickness but is shale instead of coal (10A-209).

In the southeastern corner of Paint Township, along the Paint-Walnut Creek Township line at Kolb Church, three-fourths mile west of the county line, indications of the Lower Kittanning members appear. No section could be uncovered for measurement but it is reported that the coal is of minable thickness. This is an easterly extension of a larger field which is mainly located in Walnut Creek Township to the south and west.

East of Paint Township, in Wayne and Franklin townships of Tuscarawas County, the Lower Kittanning coal has been mined extensively, especially in the vicinity of Dundee. Thicknesses up to 5 feet are reported. The character of the member is shown by a section measured in the strip mine of C. A. Wallick in SW¼SW¼ Sec. 17, Wayne Township. The character and thickness of the strata under the coal are reported by Mr. Wallick in the section which follows:

		Ft.	In.
Coal blossom, *Middle Kittanning*		0	6
Sandstone, thin-bedded		9	0
Shale, blue gray		12	0
Shale, dark blue gray, with siderite knots		10	0
Shale, dark gray, with gray siderite balls		5	1
Limestone, hard, ferruginous; (varies to 10 inches), *Hamden*		0	3
Shale, dark gray		0	5
Shale, with coaly streaks	*Lower Kittanning*	0	2
Shale, black, very hard	*Lower Kittanning*	0	1
Coal, bright, blocky	*Lower Kittanning*	0	8
Coal, bright, blocky, with some discontinuous ¼-inch to 3-inch pyrite lenses	*Lower Kittanning*	2	4
Clay, gray, plastic		3	0
"White sandy stone"		3	0
Clay, gray, "flint"		3	0

Salt Creek Township.—Land high enough in Salt Creek Township to retain the Lower Kittanning members exists only in the eastern part and in two other very small areas, one in the western central part of the township and the other in the southwestern part. The north-south ridge in the eastern part of the township, extending northward from Millers Corners through Mt. Hope to Calamoutier in the northeastern corner of the township, is so thickly covered with glacial debris that very few outcrops of bedrock are present. However, it is reported that 4 feet or more of Lower Kittanning coal of good quality has been encountered in an excavation along the Benton-Mt. Hope road between secs. 2 and 11, one-half mile west of the village of Mt. Hope, at an elevation of about 1,255 feet. A considerable area of Lower Kittanning coal may exist in minable thickness, for 1½ miles to the north, in E. central Sec. 35, the coal is reported as 4 feet 3 inches.

The Lower Kittanning members crop out around the high knob in SW¼ Sec. 32 in the central western part of Salt Creek Township. The clay has good thickness but the coal is negligible in amount (12-138, Appendix).

In the extreme southwestern corner of the township a small area of coal may reach minable thickness. A blossom of 2 feet is present in a road ditch one-fourth mile east of Prairie Township and one-fourth mile north of Hardy Township (14-13).

Prairie Township.—The Lower Kittanning members are confined to a small area in the northeastern corner of Prairie Township, with an added possibility that they may be present in very small amount in one or two knobs in the central southern portion of the township adjacent to the Hardy Township line.

In NE¼SW¼ Sec. 25 the members under discussion crop out in a lane where the coal is 3 inches in thickness and the clay underneath is impure and has a thickness of 4 feet 6 inches. The position of the coal here is 38 feet 2 inches above the Putnam Hill limestone (16-54).

The NE¼ Sec. 26 of Prairie Township rises high enough to retain the Lower Kittanning members near the top of the knob in the corner of this section, but they do not crop out. The Lower Kittanning coal is reported to reach a minable thickness of from 2 to 4 feet in Sec. 24 of Franklin Township, Wayne County,[1] which adjoins Prairie Township, Holmes County, on the north. Three-eighths mile north of the county line in NW¼SW¼ Sec. 24, Franklin Township, Wayne County, the coal and clay under consideration are exposed along the north-south road. The measurement of the coal in the following rock section may not represent the full thickness of the bed:

	Ft.	In.
Sandstone, irregular; apparently not massive; and covered	20	0
Coal, weathered, *Lower Kittanning*	0	10
Clay, light, plastic	3	2
Covered	15	0

In central southern Prairie Township the high knob south of partial Sec. 16, almost at the Prairie-Hardy township line, rises high enough above the Putnam Hill limestone to retain the Lower Kittanning members, but the hill is partially wooded and no outcrops are present.

[1] Conrey, G. W., Geology of Wayne County: Geol. Survey Ohio Bull. 24, p. 118, 1921.

Ripley Township.—It is possible that the high land in the southwestern part of this township, in SE¼ Sec. 7, in Sec. 18, and in SW¼ Sec. 17, rises high enough to retain the Lower Kittanning horizon. However, massive sandstone is present at about this horizon and it is probable that if the Lower Kittanning members were ever deposited the massive sandstone later replaced them. This massive sandstone extends downward almost to the Bedford horizon in this part of Ripley Township.

Knox Township.—The highest land in Holmes County is found in Knox Township. Bell Ridge, in the eastern part of the township, rises at places to more than 1,340 feet, and a branch of Bell Ridge extending into the central part supports a knob rising to more than 1,400 feet, which is the highest point of land in Holmes County. These high areas are of sufficient elevation to retain the Lower—and indeed also the Middle—Kittanning horizons, notwithstanding the westward rise of the strata in this part of the county.

The Lower Kittanning coal has been mined in a small way on the William E. Faler farm, 1¾ miles south of Nashville, from an opening driven into the coal just west of the north-south road across the ridge. The beds exposed in the mine and partly exposed in a lane across the road to the east are as follows:

	Ft.	In.
Base of coal in old mine, *Middle Kittanning*, covered..........	48	6
Shale, gray to buff, pyritiferous, sparingly fossiliferous, *Hamden*	10	0
Shale, black, hard, carbonaceous, (not bony)	5	6
Clay shale, gray	0	2
Coal, good, *Lower Kittanning*	2	4
Clay, (reported "like flint").		

According to Mr. Faler the coal ranged from 18 to 30 inches in thickness, but in most places in the mine it was about 2 feet thick. In driving the entry for this mine one "horse-back" was encountered. According to Mr. Charles Atha of Millersburg, who has tested the coal with the drill, the thickness ranges from 22 to 24 inches, is usually overlain by sandstone, and its position ranges from 38 to 54 feet below the Middle Kittanning coal.

On Bell Ridge, along the eastern margin of the township, the horizon of the Lower Kittanning members is occupied by sandstone.

Monroe Township.—The Lower Kittanning members are present in only a small area of Monroe Township, in the southeastern part and in a small area in the western portion. Near the top of the high ridge which trends north-south along the western part of Monroe Township, where the elevation is high enough to retain even the Middle Kittanning coal at the tops of the ridges, in only one or two places is there any indication of the Lower Kittanning coal and clay. It is thought that the Lower Kittanning coal and clay, if deposited, have been later removed by erosion and their place taken by massive sandstone, as it is in many places along Bell Ridge, 1 to 2 miles west, in the eastern part of Knox Township.

Just east of the road fork one-half mile west of Birds School in the southwestern part of Monroe Township, at an elevation of approximately 1,250 feet, a coal blossom more than 1 foot thick which may be Lower Kittanning is present, together with obscured beds above and below (36-313). At other places along this ridge no outcrops of the Lower Kittanning members were seen.

In the southeastern corner of Monroe Township a small area adjacent to Hardy Township and three-fourths mile north of Killbuck Township is underlain by Lower Kittanning coal almost 2 feet 6 inches in thickness and possibly more at places. This is the western part of a much larger area in Hardy Township in which several small mines have operated.

Hardy Township.—The Lower Kittanning beds are present in several moderately sized and widely scattered areas in Hardy Township. The coal attains a minable thickness in the northeastern, the southeastern, and the southwestern parts of the township.

In Sec. 4 in the northeastern corner of this township, the Lower Kittanning members are present and in the eastern and northern parts the coal has a minable thickness. In NW¼ Sec. 4 the Putnam Hill limestone is exposed just below the road fork, and the Lower Kittanning members are exposed up the road to the north, where the coal is 3 feet 4 inches in thickness (45-65, Appendix). The Lower Kittanning coal was formerly mined in NE¼SE¼ Sec. 4 on the farm of Eli B. Miller. It is reported that the coal has a thickness of from 3 to 4 feet, and is described as "peacock" coal. The roof was said to be sandstone. Nearby the members crop out along a road ditch where the coal is 2 feet 3 inches in thickness and the underlying clay is 6 feet 5 inches (46-63.)

In NW¼NE¼ Sec. 14 the Lower Kittanning members are due but are concealed by glacial drift. In the central part of Hardy Township, just north of the Millersburg corporation line, along the Millersburg-Benton road, Lower Kittanning coal 5 inches in thickness is exposed near the top of the hill, 31 feet above the underlying Putnam Hill limestone (57-124). The coal is overlain by 12 feet of massive, coarse sandstone such as is commonly found above the Lower Kittanning members in many parts of Holmes County.

The most important areas of Lower Kittanning coal in Hardy Township are in the southwestern part where many mines have been opened. Much coal has been removed, but a considerable quantity remains. Along the ridge road north of Uhl Run, a mile east of Monroe Township, the Lower Kittanning coal has been mined at several places where the thickness is about 3 feet. Here the interval from the Lower Kittanning coal to the Putnam Hill limestone is 33 feet as measured along the road (52-

276, 53-277). The full thickness of the clay was not observed at any clear outcrops. The roof in most places is sandstone.

The Lower Kittanning members underlie the ridge which extends from a mile west of Millersburg toward the southwestern corner of Hardy Township, where the ridge divides, one branch extending into northwestern Killbuck Township and the other into southeastern Monroe Township. This is the divide between Uhl Run and the tributaries of Killbuck Creek. The Lower Kittanning coal in the westward extension of this ridge in Monroe Township has already been discussed. Five-eighths of a mile from both the Killbuck and Monroe township lines, in the head of gully north of the road, an entry has been driven into the Lower Kittanning coal on the farm of Phillip Collier, the coal being leased by William Hall. Lower Kittanning coal has also been mined nearby on the Charles Tidball farm by Urick and Ling, and on the farm of the Cullen heirs by Low Korns. The structure of the Lower Kittanning coal in the Collier mine is shown by the following section:

		Ft.	In.
Sandstone.			
"Soapstone" (reported).			
Shale, dark, carbonaceous, rather soft		4	0
Coal, hard, bony	*Lower Kittanning*	0	4
Coal, good	*Lower Kittanning*	1	7
Shale, coaly, soft	*Lower Kittanning*	0	1
Coal, good	*Lower Kittanning*	1	5
Clay		3	0

One-eighth mile north of the Killbuck Township line and seven-eighths mile east of Monroe Township, at the head of the south fork of Hardy Run, the coal has been mined by the Gwin and Mathie Coal Company. When visited, it was impossible to enter the mine because of a fall of the roof. The owners report that the measurements of the bed are as follows:

		Ft.	In.
"Gray slate" to almost a "soapstone."			
Coal, good	*Lower Kittanning*	1	10
"Dirt band," (shale, pyritiferous and carbonaceous), 1/16 to 1 inch thick	*Lower Kittanning*	0	½
Coal, good	*Lower Kittanning*	1	6
Clay		3	6

One-quarter of a mile north of the Gwin and Mathie mine, at the head of the north fork of Hardy Run, the Lower Kittanning coal was formerly mined extensively from an opening called the "Bowen Mine" (54-290). Coal from the Bowen mine was let down the valley in heavy cars on a tramway to a point 400 feet below the Leasure (Shevilard) mine in the Bedford coal. The coal was then loaded into railroad cars on a Pennsylvania Railroad switch.

A core drill test east of the road, about midway between the location of the now abandoned Gwin and Mathie and Bowen mines, found 6 feet 8 inches of carbonaceous material at the Lower Kittanning clay horizon, of which 6 feet is coal, as shown in detail in 55-401, Appendix. In this drill core no Lower Kittaning clay is present.

No clear and unweathered sections could be uncovered for measurements along the ridge one-half mile north of Killbuck Township and from 1 to 2 miles east of Monroe Township, but there are indications that coal of minable thickness may underlie the ridge.

One mile north of Killbuck Township and 1⅞ miles east of Monroe Township, just south of the east-west road, coal has been taken from time to time for local use from an opening in the Lower Kittanning coal, which in this mine has more partings than usual. The measurements in the mine follow:

		Ft.	In.
Sandstone, white, coarse		5	0
Sandstone, coarse; with coaly streaks		1	0
Shale, dark, coaly	*Lower Kittanning*	0	½
Coal, bony		0	2
Shale, dark		0	¼
Coal, good		0	11
Shale, dark		0	½
Coal, good		0	9½
Shale, dark		0	3/16
Coal, good		0	7½
Clay, light, plastic, good		2	0

In the southeastern part of the township, the Lower Kittanning members crop out in SW¼ Sec. 14 at the 1,174-foot road forks at Armours School. Exposures are poor, but the interval from the underlying Putnam Hill limestone to the Lower Kittanning coal is measured as 40 feet. The Lower Kittanning members are poorly exposed near the top of the ridge in NW¼SE¼ Sec. 17, where 6 inches of Lower Kittanning coal is present (61-24).

The Lower Kittanning members underlie the ridge in the southern part of Sec. 24, where in places the coal attains a minable thickness. The erratic and unsteady character of the Lower Kittanning coal is shown in NE¼SE¼ Sec. 24 on the farm of Carson Jones. On the outcrop the Lower Kittanning coal is 18 inches in thickness and one-half mile to the west satisfactory mines have been developed. It was supposed that the 18 inches would increase as the entry was driven into the hillside, so a mine was started. Fifty feet from the opening, however, the member passes into carbonaceous shale with a few inches of coal (63-41). In SE¼SW¼SW½ Sec. 24, one-half mile west of the Jones opening in the Lower Kittanning bed, a small mine has been opened where the coal is 2 feet 7 inches in thickness and of good quality.

Berlin Township.—The Lower Kittanning members are found throughout the eastern part, in the southwestern part, and in a very small area in the northwestern part of Berlin Township. The erosion of pre-last-glacial Martins Creek has so lowered the central part of Berlin Township that the Allegheny beds have long since been eliminated. Much Lower Kittanning coal has been removed from many openings in eastern Berlin Township, particularly from the vicinity of Berlin village. Coarse sandstone, generally massive, but at some places thin-bedded, overlies the coal in Berlin Township. At places the sandstone forms the roof of the coal, at other localities a few feet of shale intervenes between coal and sandstone.

The Lower Kittanning members should underlie most of Sec. 4 and E½ Sec. 5, in the northeastern corner of Berlin Township, but owing to the thick cover of glacial drift no identifying outcrops are present. The members under discussion crop out in a road excavation just beyond the glacial boundary in NE¼SW¼ Sec. 7, which the coal is 2 feet 6 inches in thickness. The coal has been mined somewhat more than one-half mile east in Sec. 8, Walnut Creek Township.

In central partial Sec. 14 there is a Lower Kittanning coal blossom along the road at an elevation of approximately 1,210 feet. About one-fourth mile east, just north of the road, the bed was measured in the local mine of F. J. Brown where the coal and overlying Hamden marine horizon are as follows:

		Ft.	In.
Shale, carbonaceous, fossiliferous, *Hamden*		12	0
Coal, with "dirt" and "sulfur" streak	*Lower Kittanning,* altitude 1,210 feet	0	4
Coal, good		2	8
Clay, light, plastic		1	0

The thickness of the Lower Kittanning coal is somewhat less where it crops out along the road between secs. 14 and 15, one-eighth mile south of South Bunker High School. The strata have the following measurements:

	Ft.	In.
Shale, with iron nodules	5	0
Coal, weathered, *Lower Kittanning*, altitude 1,215 feet	1	5
Clay shale	3	0

The Lower Kittanning coal was formerly mined at the northeast edge of the village of Berlin. Just north of the village in SW¼SW¼ Sec. 6, 2 feet 1 inch of coal is exposed along the road (66-91). The Lower Kittanning coal underlies the village of Berlin, and was formerly mined from several openings, the principal ones of which were south of the village. South of the state road to Sugar Creek, three-sixteenths mile south of the state road fork in the eastern part of Berlin, a shaft from the surface to the Lower Kittanning coal was sunk in 1927 by Delbert Hitchcock on the G. W. Beachy farm. Several drill tests had been made to insure the presence of the coal under the farm by Mr. Hitchcock, who reports the following measurements from the shaft and from records of holes to the Brookville horizon:

	Ft.	In.
"Soil"	9	0
Sandstone, thin-bedded	5	0
Sandstone, massive, blue gray; with plant fossils and coaly streaks	9	0
Coal, *Lower Kittanning*	3	4
Clay shale, "fire clay"	39	0
Limestone, *Putnam Hill*	4	0
Coal smut, *Brookville,* a few inches.		

In 1928 the shaft was completed, the main entry driven to the west and several rooms turned off the entry. Mining was very difficult because the beds here dip to the west into the syncline whose axis approximately parallels Killbuck Creek. Thus the water followed down the workings and the rooms were always wet and difficult to drain. For this reason the mine was soon abandoned.

The Lower Kittanning coal was formerly mined 1 mile south-southwest of Berlin on the farm of D. J. Hitchcock, where the coal is reported to be somewhat more than 3 feet, but the upper 1 foot bony (71-45).

The Lower Kittanning members are present in a small area in northwestern Berlin Township, underlying the hill west of Buena Vista School. The strata exposed in a road ditch at the crossroad one-eighth mile west of the school, at the eastern margin of partial Sec. 8, are as follows:

	Ft.	In.
Shale, sandy, ferruginous	8	0
Clay, gray	1	0
Coal, weathered, *Lower Kittanning,* altitude 1,205 feet	1	10
Clay, light, plastic, with yellow streaks	5	0
Clay shale, with iron concretions	10	0

Just east of the Hardy Township line in SW partial Sec. 13, along the state road from Millersburg to Berlin, the Lower Kittanning coal consists of 8 inches of carbonaceous shale (60-66). In Sec. 13 one-half mile east of Hardy Township, at an elevation of approximately 1,190 feet, the Lower Kittanning members are poorly exposed.

The Lower Kittanning coal apparently does not reach minable thickness in the southwest corner of Berlin Township. Three feet of Lower Kittanning clay crops out near the crossroad five-eighths mile north-northeast of Saltillo, but the coal is absent here. The position of the Lower Kittanning members is shown along the east-west road five-eighths mile from Hardy Township and five-eighths mile from Mechanic Township, just east of Sec. 23. The thickness of the clay here is small and the following measurement shows that the coal has practically disappeared:

	Ft.	In.
Sandstone, coarse	50	0
Coal smut, *Lower Kittanning*	0	½
Clay	2	0
Covered	11	4
Clay shale, with ore balls	15	0
Coal blossom, *Brookville,* altitude 1,140 feet	0	6
Clay	3	0
Sandstone, ganister-type	3	0
Sandstone, shaly	28	0
Shale	17	0
Coal, blossom, *Bedford*	0	6

As is the case in some parts of Holmes County, the Lower Kittanning coal in the section given is overlain by coarse sandstone. The sand grains are of white quartz, uniform in size, and rather angular. The color of the sandstone where unweathered is white, gray, or light buff, but it is rarely seen in the unweathered state. The cementing material is mostly iron oxide which weathers easily and discolors the sandstone, and most weathered blocks are brown or dark brown on the surface. The sandstone breaks up very readily and along the road produces a noticeably deep sand, most of which is dark yellow in color. This sandstone is ordinarily very massive at fresh exposures but at a few places, as in the section above, it is composed in part of beds 1 to 2 inches in thickness. There is some cross-bedding and variation of thickness, some of the beds being up to 6 inches thick. At other places 2 to 4 foot beds are present. At some places the Lower Kittanning coal is overlain directly by the sandstone, as at the section given above, but at many other places, notably in the Berlin coal field, carbonaceous shale or clay shale called "soap-stone," representing the Hamden horizon, is present. Where sandstone is present immediately above the coal it makes an excellent roof; where "soap-stone" is present the roof qualities of Lower Kittanning coal mines are distinctly inferior.

In southeastern Berlin Township the Lower Kittanning coal is generally of minable thickness and of fair quality. The coal was formerly mined from an opening one-fourth mile south of the 1,259-foot road fork with the state road one-fourth mile west of Walnut Creek Township, where the Lower Kittanning coal is 52 feet below the base of the overlying Middle Kittanning coal. One-half mile south-southeast of this abandoned mine, 100 yards west of Walnut Creek Township, and 1¼ miles north of Clark Township, the Lower Kittanning coal was measured in the mine of Ben Yoder. The underlying Brookville coal causes a line of springs farther down the hill, and the beds above the Lower Kittanning coal were reported by Mr. Yoder from drill records obtained when prospecting for the Lower Kittanning coal. The section follows:

		Ft.	In.
Coal blossom, *Middle Kittanning*		1	0
Interval		61	0
Clay shale, gray, a few marine fossils, *Hamden*		1	0
Coal, shaly and bony	*Lower Kittanning*	0	3
Coal, good	*Lower Kittanning*	3	1
Clay, reported		5	0
Covered		47	0
Coal, *Brookville,* altitude 1,150 feet		0	3
Covered		44	0
Stream level.			

Southward, close to the Clark Township line, the coal appears to thin, and at places is only a few inches in thickness (84-137, 74-85).

Walnut Creek Township.—Some of the most important areas of Lower Kittanning coal are found in Walnut Creek Township. Relatively large amounts of the coal have been mined near Trail in the northern part of the area. Scattered small mines in the bed may be found at many other places along the outcrop of the coal throughout the township. The beds under discussion lie high up near the tops of the ridges so that the areas are small but well distributed. The coal in most places in the township has, or approaches, a minable thickness. It is almost everywhere overlain by the Hamden fossiliferous marine shale.

In the northeastern part of the township the east-west ridge, about a mile south of the village of Trail, is underlain by the Lower Kittanning members and the coal has been mined on both sides of the ridge. The elevation of the Lower Kittanning coal here is approximately 1,170 feet. In NE¼SW¼ Sec. 5 the coal has a thickness of 3 feet 10 inches (for details and analyses see "Economic Value"). It is reported that coal as thick as 6 feet has been encountered in mining operations. The Lower Kittanning coal continues to the east with good thickness, where it is mined in western Wayne Township, Tuscarawas County (75-197, Appendix).

In the local mine of Elton Miller, three-eighths mile east of the 1,156-foot crossroad 1 mile south of Trail, the Lower Kittanning coal is overlain by very fossiliferous Hamden marine shale, as well shown in the following section:

		Ft.	In.
Shale, dark, carbonaceous; abundant pyritized fossils, *Hamden*		3	0
Coal, good	*Lower Kittanning,* altitude 1,180 feet	0	10
Shale, dark, pyritiferous	*Lower Kittanning,* altitude 1,180 feet	0	½
Coal, good	*Lower Kittanning,* altitude 1,180 feet	0	9½
Pyrite	*Lower Kittanning,* altitude 1,180 feet	0	½
Coal, good	*Lower Kittanning,* altitude 1,180 feet	2	1
Shale, dark, coaly, soft	*Lower Kittanning,* altitude 1,180 feet	0	2
Clay, sandy, impure		3	6
Shale, with discontinuous 1- to 2-inch beds of white sandstone		5	0

The Lower Kittanning coal has been almost entirely mined out from the top of the hill just west of the Trail-Walnut Creek road, a little less than a mile southwest of Trail. Former miners in this area report that the coal underlying this hilltop was about 6 feet in thickness. In one or two places in this locality a thickness of 7 feet of good coal is reported to have been mined.

The Lower Kittanning coal attains a minable thickness in the northwestern corner of Walnut Creek Township, just south of Paint Township. It has been mined from openings in the latter township, (5-227). The ridge between Indian Trail Creek and Goose Creek, in the northwestern part of the township, is underlain by a considerable area of Lower Kittanning coal (81-224.)

The ridge north of Goose Creek, which extends from west to east almost across the township, is underlain by the Lower Kittanning members. The coal has been mined from the central part of the ridge, where the thickness is about 3 feet.

The ridge south of Goose Creek, along the crest of which runs the Berlin-Walnut Creek state road, is underlain by Lower Kittanning coal having a thickness of about 3 feet in the western part (82-97, 86-120). Just north of Walnut Creek, along the Walnut Creek-Trail road, the Lower Kittanning coal is 1 foot 8 inches and the underlying clay, 4 feet (87-107). Farther east along the ridge the Lower Kittanning clay has a thickness of 9 feet in NW¼ Sec. 16 (89-132). The apparent thickness may be greater than the actual because of slumping. The coal here, however, is but 6 inches in thickness.

In the southwestern part of the township several poor exposures of the coal indicate that its thickness is about 2 feet, but it may vary considerably from this figure. The roof is commonly fossiliferous Hamden shale (83-99, 84-137, 85-119).

The Lower Kittanning coal in fair thickness underlies the high land southeast of Walnut Creek. It was formerly mined in SE¼ Sec. 25, where the thickness is reported as approximately 2 feet 9 inches. The clay measured along the road has a thickness of 5 feet 4 inches (93-134). In this locality the Lower Kittanning coal is overlain by several feet of ferruginous, carbonaceous, fossiliferous Hamden shale, which makes a very poor roof under which it was at times dangerous to work. Consequently, mining operations here were never very successful or extensive.

The Lower Kittanning coal was formerly mined from several openings on either side of the state road from Walnut Creek to Sugar Creek, 1 mile west of Cigar Ridge School, in NW¼ Sec. 5. The thickness of the coal is reported as 2 feet 4 inches (92-190).

Clark Township.—Because of its southeastern position in Holmes County, Clark Township has the largest area of Lower Kittanning members of any of the townships in the county. The general southeast dip of the beds, modified in the central part of the county by the Millersburg syncline, is resumed and again becomes general in Clark Township.

In the northeastern corner of Clark Township the Lower Kittanning coal and clay were not seen in SE¼ Sec. 5 but it is reported that the coal is 2 feet 6 inches in thickness in an old opening now fallen in. In SE¼ SW¼ Sec. 5 the position of the members under discussion was seen along the road. It is quite possible that the thickness of the coal is somewhat greater under cover than indicated in the following section secured along the road:

	Ft.	In.
Shale, siliceous, grading upward to sandy	68	0
Clay, and covered, *Middle Kittanning*	3	0
Shale, clay-like, ferruginous, especially in lower half	48	0
Coal blossom, *Lower Kittanning*, altitude 1,130 feet	1	0
Clay	4	0
Shale	20	0

Lower Kittanning members crop out in SE¼SW¼ Sec. 1, about one-fourth mile north of the hamlet of Unionville, where the following measurements were secured along the road:

	Ft.	In.
Clay shale, with small iron concretions	6	0
Coal, weathered, *Lower Kittanning*, altitude, 1,150 feet	1	4
Clay, light, plastic	8	1
Clay, sandy, ferruginous	3	3
Shale, sandy	12	0

East of Unionville the Lower Kittanning coal is very thin or absent in SW Sec. 7, SE Sec. 6, NE Sec. 15, and NW Sec. 14. The clay, however, attains a good thickness and seems to be of fair quality. Where the beds crop out along the road in SW¼ Sec. 7 and NW¼ Sec. 14, the coal is absent but the clay has a thickness as follows:

	Ft.	In.
Sandstone, thin-bedded and deeply weathered	18	0
Clay, plastic, light, good; partially covered, *Lower Kittanning*, altitude 1,090 feet	7	0
Shale, clay shale; and covered	80	0

An interesting and significant example of the way in which conglomerate and coarse sandstone may cut out the coal bed is shown in NE¼ Sec. 12 along the road one-eighth mile southwest of Farmerstown. Almost 6 feet of Lower Kittanning clay, lying 46 feet above the Putnam Hill limestone, is immediately overlain by 3 feet 6 inches of quartz pebble conglomerate within which are discontinuous streaks of coal up to 2½ inches in thickness. The conglomerate is overlain by 26 feet of coarse sandstone (97-168).

The Lower Kittanning members crop out near the road fork in NW¼NE¼ Sec. 9, at an elevation of approximately 1,110 feet, but are poorly exposed. The Lower Kittanning coal is represented by a few thin, carbonaceous, shaly streaks in a siliceous shale, bearing plant fossils, in NE¼SW¼SW¼ Sec. 8, where the beds crop out along the Charm-Farmerstown road (99-170). The associated clay is thin and impure. The Lower Kittanning coal horizon is 36 feet 8 inches below the base of the overlying Middle Kittanning coal.

The Lower Kittanning coal ranges from 1 to 6 inches in thickness in Sec. 4, in the northwest part of the township, where it crops out along several roads. The underlying clay, of fair to good quality, is about 6 feet in thickness. The interval from the Lower Kittanning coal to the underlying Putnam Hill limestone is rather steady and approximately 27 feet.

In NE¼SW¼ Sec. 15 Lower Kittanning coal having a thickness of 3 feet 6 inches is reported to have been mined; but in this section the coal is erratic in thickness, and at most places is probably not more than 1 foot near the Mechanic Township line in secs. 6 and 15.

In the southwest corner of Clark Township the coal is either wanting or has a negligible thickness. A spring line and an uncertain outcrop of clay at an altitude of 1,144 feet are present along the road in SE¼NE¼ Sec. 16, but coal was not seen. This horizon is 56 feet below the overlying Middle Kittanning coal and 44 feet above the underlying Putnam Hill limestone, which is exposed farther down the hill along this road (108-185).

In central southern Clark Township the Lower Kittanning members again attain a more prominent place in the stratigraphic section. In SW¼NE¼ Sec. 22 the Lower Kittanning coal and clay show the following relations in an excellent road bank exposure:

	Ft.	In.
Shale, siliceous	10	0
Coal, weathered, (full thickness), *Lower Kittanning*, altitude 1,110 feet	1	5
Clay, light, plastic, siliceous	4	0
Clay, very sandy; or sandstone, clay-bonded	3	0
Shale, siliceous	10	0

Near the crossroad at the line between secs. 21 and 22, the coal has a thickness of 6 inches; the clay underneath is 8 feet thick. At this place the coal is approximately 31 feet below the Middle Kittanning coal horizon. The coal increases in thickness eastward and in the central part of Sec. 21 it is 1 foot 10 inches (111-154). The position of the Lower Kittanning members in relation to the underlying Putnam Hill limestone is excellently shown in SE¼SE¼ Sec. 21, along the road up to the Holmes-Coshocton county line, just northwest of the Baltic corporation line (112-153). At this locality the coal has increased to 2 feet 2 inches in thickness.

The Lower Kittanning coal is as much as 4 feet in thickness in SE¼ Sec. 25, northeast of Baltic, in the shale pit of the General Clay Products Company, but in general is much thinner. At times the coal has been used with the Middle Kittanning coal for burning the ware. The clay is used along with shale in the manufacture of tile.[1] The section which follows records the thickness and character of the Lower Kittanning members and the unusually short interval between the Kittanning coals as exposed in the pit in 1944:

		Ft.	In.
Shale, weathered; and soil		6	0
Shale, gray to tan, siliceous		31	0
Shale, black, carbonaceous, fissile		4	11
Shale, dark, carbonaceous, sandy, pyritiferous, *Washingtonville*		1	8
Coal, bright, good, *Middle Kittanning*		3	1
Clay, plastic, siliceous to sandy		4	5
Sandstone, white, clay-bonded		3	7
Shale, gray, siliceous		7	7
Coal, bony, hard	*Lower Kittanning*	0	1
Coal, bright	*Lower Kittanning*	1	2
Pyrite	*Lower Kittanning*	0	½
Coal, with discontinuous pyrite streaks	*Lower Kittanning*	0	3½
Pyrite	*Lower Kittanning*	0	½
Coal, bright, good	*Lower Kittanning*	0	10
Clay, dark, plastic		0	5
Clay, gray, plastic, siliceous to sandy		6	6
Clay, gray, very sandy, in part micaceous; with very hard, sandy streaks		7	5
Bottom of pit.			

The structure of the Lower Kittanning coal is well shown in the mine of Hoobler and Eiler Brothers, one-fourth mile south of Clark Township, in SE¼NE¼ Sec. 5, Bucks Township, Tuscarawas County, where the following section was measured:

		Ft.	In.
Coal, old mine, *Middle Kittanning*		2	6
Clay shale, and covered		22	0
Clay shale, gray		1	0
Shale, black, coaly	*Lower Kittanning*	0	5
Coal, good	*Lower Kittanning*	2	½
Shale, coaly	*Lower Kittanning*	0	½
Coal, good	*Lower Kittanning*	0	8½
Clay, (bottom not seen)		2	0

Along the road just southeast of the Baltic corporation line the interval is only 18 feet from the base of the Lower Kittanning coal to the base

[1] Lamborn, R. E., Shales and Surface Clays of Ohio: Geol. Survey Ohio Bull. 39, p. 168, 1938.

of the overlying Middle Kittanning coal. The Lower Kittanning coal along the road is 1 foot 6 inches in thickness. Both of the Kittanning coals crop out in the cut of the Wheeling & Lake Erie Railroad one-half mile south of Baltic, the interval between them being unusually short.

The Lower Kittanning coal appears to have a thickness of 2 feet or more almost everywhere it is present in Sec. 24 in the extreme southeastern corner of the township. Along the road in NE¼SW¼ Sec. 24 the bed is weathered on the outcrop and the blossom probably is not the full thickness of the coal (116-147). The Lower Kittanning coal has been mined in a small way in SW¼NE¼ Sec. 24; the Putnam Hill limestone has been quarried down the hill below the mine in the bed of a small run (115-148).

The roof conditions of the Lower Kittanning coal in the southeastern part of Clark Township are regarded as rather poor because clay shale overlies the coal. This is in contrast to the sandstone roof present at many places to the north and northwest, in Holmes County, which makes mining much easier and safer. Although the Lower Kittanning coal reaches a good thickness in southeastern Clark Township, it is not mined extensively because the Middle Kittanning coal is also present in large amount and the roof conditions over this bed are much more favorable than those over the Lower Kittanning.

Mechanic Township.—Relatively small areas near the tops of hills and ridges in the eastern, northeastern, northern, and western parts of Mechanic Township are high enough to retain the horizon of the Lower Kittanning members. In the eastern part of Mechanic Township the coal is thin and is not known to reach minable thickness, but in the western part the coal is thick enough to mine in a few places.

The horizon of the Lower Kittanning members remains uneroded near the top of the hill in NW¼ Sec. 1 in the northeastern corner of Mechanic Township but no clear section could be secured for measurement. A coarse sandstone 30 feet in thickness overlies the Lower Kittanning beds at this place (122-78, Appendix). The northern and eastern parts of Sec. 2 rise high enough to retain the Lower Kittanning members, which are known from outcrops just to the north in Berlin Township, but no exposures are evident in Sec. 2. The high ridge upon which Saltillo is built, extending for a mile to the south and thence west past Grade to the edge of Killbuck Valley, retains the Lower Kittanning horizon near its top. The Lower Kittanning strata were not seen in Sec. 3, south of Saltillo, but 1 mile southwest of that hamlet, along the east-west road, 6 inches of Lower Kittanning coal is underlain by 4 feet of light, plastic Lower Kittanning clay, at an elevation of approximately 1,165 feet (128-40). A yellow, coarse sandstone, 20 feet in thickness, immediately overlies the coal. No other good exposures are present along the top of the ridge between Saltillo and Grade, but from those indications noticed, it is probable that at all places along the ridge the Lower Kittanning coal is thin.

One mile northwest of Grade, in SW¼NE¼ Sec. 1 (northwest corner of the township), the Lower Kittanning horizon is well exposed along the bank of the old Millersburg-Coshocton state road near a road fork. The Lower Kittanning clay is absent and the coal consists of shaly, carbonaceous sandstone streaks in a coarse sandstone (133-36). These bands represent reworked remnants of Lower Kittanning coal which has been cut out and mostly removed by strong currents which also brought in the sandstone.

The Lower Kittanning coal rapidly thickens at the western edge of Mechanic Township as the Killbuck-Hardy field is approached. One foot 6 inches of coal is well exposed along the east-west road in E Sec. 2 (134-34). From outcrops to the west across the Killbuck Township line, which show the Lower Kittanning coal to have a minable thickness, it is believed that the member may be of fair thickness at some places in SW Sec. 9. The northwest part of Sec. 12 is underlain by Lower Kittanning coal of fair thickness, some of which has been removed by mining operations (135-4). Data reported from test pits and drilling exploration by Mr. Ned W. Andrix in this section show that although the Lower Kittanning coal at places is more than 4 feet in thickness it is very erratic and may be reduced to only a few inches in thickness in a short distance, or may even be missing entirely.

The Lower Kittanning horizon is retained near the top of the ridge in NW¼ Sec. 19, but no detailed measurements of the beds could be secured (137-68).

Near the central eastern and southeastern margin of Mechanic Township two small areas have sufficient elevation to retain possibly the Lower Kittanning membrs. The east-west ridge in central Sec. 11, southeast of Becks Mills, rises high enough above the Brookville coal (the Putnam Hill limestone being absent through lack of deposition) for the retention of the Lower Kittanning members, but field evidence shows that the beds are very thin and negligible in amount. A considerable part of Sec. 20 is of sufficient height to retain the Lower Kittanning members. Although no very clear sections of the coal and clay are present for accurate measurement, indications in Sec. 20 are that the beds are thin, especially the coal.

Killbuck Township.—With the exception of a small area underlain by the Lower Kittanning members along the central part of the northern boundary of Killbuck Township and another in the extreme southwestern corner, these members are confined to the central eastern part of the township. Although the area of the Lower Kittanning coal and clay in this township is small, the thickness of both coal and clay is much higher than the average throughout Holmes County, and the coal has been extensively mined. The Lower Kittanning clay has good thickness and quality, and it constitutes a future resource of value.

An extension of the Lower Kittanning coal field, whose main part is in southwestern Hardy Township, lies in NE¼ Sec. 5 and NW¼ Sec. 4. The coal is overlain by massive sandstone, with from 1 to 10 feet of shale intervening. The coal is mined in SW¼NE¼NE¼ Sec. 5 by C. A. Hughes at the Star coal mine, in which it is reported the coal ranges from 2 feet 4 inches to 3 feet 6 inches in thickness. A measurement in the main entry is as follows (see also 141-288):

		Ft.	In.
Shale, black, carbonaceous, not continuous	*Hamden*	1	6
Coal, with thin shale partings	*Lower Kittanning,* altitude, 1,170 feet	0	6
Coal, bright, blocky		1	5
Pyrite		0	¾
Coal, bright		0	6
Pyrite		0	¾
Coal, bright, blocky		0	10
Clay, gray, plastic; (not entire thickness)		2	0

In the eastern part of the township the Lower Kittanning members are present in parts of secs. 7, 8, 13, 14, and 18. From the southeast part of Sec. 8, on the farm of M. Shepler, the following data are reported:[1]

		Ft.	In.
Shale, black.			
Coal, good	*Lower Kittanning*	4	3
Coal and shale, not good		0	6

It is interesting to note that in this field in the eastern part of Killbuck Township, part of the Lower Kittanning coal bed consists of cannel coal. The cannel coal generally occurs through the central part of the bed, being underlain and overlain by bituminous coal, as shown by the following section secured in an old mine on the farm of Ed. Shepler in NE Sec. 13:[2]

		Ft.	In.
Shale, gray		4	0
Shale, gray to dark, sandy		4	6
Shale, gray, with dark streaks		1	0
Shale, coaly	*Lower Kittanning,* altitude 1,145 feet	0	10
Coal, bituminous good		1	5
Coal, cannel		0	8
Coal, bituminous, good		1	8
Clay, plastic, light		3	0

[1] Stout, Wilber, personal communication.

[2] *Ibid.*

Drilling tests in E½ Sec. 13 show that the Lower Kittanning coal is very irregular, ranging from a thin film to 6.1 feet in thickness, and that in places the coal is replaced by sandstone or sandy shale.[1]

A large mine was formerly operated by G. C. Quillen and Sons in NE¼NW¼ Sec. 13. The coal was shipped by truck to Millersburg and the surrounding country. At one time a railroad switch extended from Hardy Junction, part way up to this mine, but the tracks have been removed. The clay under the coal is reported by Mr. Quillen to be more than 6 feet thick and apparently of good quality. The partings and divisions of the Lower Kittanning coal bed and the position of the cannel coal layers are shown in the following section measured in the mine. Another section and an analysis are given under "Economic Value" and the stratigraphic relations shown in 148-31, and 149-32, Appendix.

		Ft.	In.
Shale, dark		2	0
Shale, black, hard; good roof		1	0
Coal, cannel	*Lower Kittanning,* altitude 1,128 feet	0	6
Coal, bituminous, good		2	0
Pyrite		0	1/16
Coal, cannel		0	4
Shale, dark		0	¼
Coal, bituminous, good		2	1
Clay, plastic, light.			

At another opening into the coal underlying the Quillen property, in NW¼NW¼ Sec. 13 just south of the road, the following measurements were made:

		Ft.	In.
Soil		3	0
Clay, white, plastic, *Oak Hill?*		1	0
Shale, soft, gray to dark		2	0
Shale, black, hard		3	0
Shale, bone, black, hard		2	0
Coal, bituminous, good	*Lower Kittanning*	1	8
Coal, cannel, shaly in places		0	6
Coal, bituminous, good		2	0
Clay, plastic		6	0
Shale, gray; grades downward from clay-like shale to siliceous shale		3	0

The Lower Kittanning members are very close to the top of the ridge in N½ Sec. 14 and the coal, although of fair thickness, is somewhat weathered (147-273).

A very small area of Lower Kittanning coal and clay underlies SW¼SW¼ Sec. 23 in the southwestern corner of Killbuck Township at an elevation of approximately 1,240 feet. The area is larger to the south, in NE Sec. 4 and NW Sec. 3 of Monroe Township, Coshocton County,

[1] Records made available by Ned W. Andrix, November, 1944.

where one-fourth mile south of the county line the coal has been mined by stripping by the Blue Crystal Mining Company. The coal exposed in the strip pit is 3 feet in thickness and is bright and blocky, exhibiting no continuous partings.

Richland Township.—Because of the rise of the beds to the west, the Lower Kittanning horizon has been eroded from all of Richland Township except a small area in the central part and a small area in the southwest corner. In NE Sec. 11 and NW Sec. 15 on French Ridge, the horizon of the Lower Kittanning is due but is occupied by a coarse, massive sandstone which extends downward to the horizon of the Putnam Hill limestone and there lies upon (or is continuous with?) the massive Homewood sandstone, so that the strata for approximately 90 feet above the Bedford coal are composed of coarse sandstone. This situation is analagous to that several miles north in eastern Knox Township and in western Monroe Township, where sandstone replaces the Lower Kittanning members. The sandstones in these two localities, which are separated by the valley of Black Creek runnng through Glenmont, are correlative.

In the southeastern corner of Richland Township a small area of Lower Kittanning coal is present in SW¼ Sec. 24, extending southward into Sec. 4 of Monroe Township, Coshocton County. The coal lies about 30 feet above the Putnam Hill limestone. The coal has been mined on the farm of Marion Snow. It is very bright, highly anthraxylous coal, which ignites and burns easily, making a hot fire. The ash is red and has a tendency to form clinkers. A measurement in the mine is as follows:

		Ft.	In.
Shale, gray.			
Shale, black, carbonaceous		1	2
Coal, cannel, bony	*Lower Kittanning*	0	3
Coal, bright, blocky, very clean	*Lower Kittanning*	2	7
Clay, gray, plastic.			

ECONOMIC VALUE

The Lower Kittanning coal is widely distributed and the most important coal bed in Holmes County. The position of its outcrop is shown on the geologic map of the county. The character and thickness of the bed and the roof conditions are discussed in detail in township descriptions.

The coal is at many places erratic in thickness, somewhat more so in the central and western parts of the county than in the eastern part. Test drilling is an especially important part of planning operations.

The Lower Kittanning coal is bright, banded, blocky, bituminous coal. Only in Killbuck Township is there any considerable part of the bed made up of cannel coal. The bed locally has partings of dark shale but these are irregular and cannot be traced for considerable distances. The coal burns freely and has a good heating value. The ash content is moderate to low if the partings are rejected in mining or removed in a cleaning plant. The sulphur content is slightly more than average for the Lower Kittanning coal throughout Ohio.[1] Two analyses of the coal from Holmes County are available.[2]

"Sample of Lower Kittanning coal taken in 1928 by W. S. Glock and L. O. Naffziger from mine of Yost and Ed. Miller in west central Section 5, Walnut Creek Township, Holmes County. Analysis by D. J. Demorest.

		Ft.	In.
Shale, roof.			
Coal, sampled	*Lower Kittanning*		10½
Shale, bony, pyritiferous, rejected	*Lower Kittanning*		1¾
Coal, sampled	*Lower Kittanning*		6
Shale, pyritiferous, rejected	*Lower Kittanning*		1¼
Coal, sampled	*Lower Kittanning*	2	3
Clay, floor.			

Proximate analysis

		As received	Moisture free
Moisture		6.34	0.00
Volatile matter		43.21	46.13
Fixed carbon		44.06	47.05
Ash		6.39	6.82
		100.00	100.00
Sulphur		3.65	3.90
Air drying loss 2.39 per cent			
Heating value	Calories	6,973	7,444
	B. t. u.	12,551	13,400
Fusion of ash	Incipient	2,180°F.	
	Complete	2,402°F.	

Sample of Lower Kittanning coal taken in 1928 by W. S. Glock and L. O. Naffziger from mine of G. C. Quillen & Sons, in northwest quarter of Section 13, Killbuck Township, Holmes County. Analysis by D. J. Demorest.

		Ft.	In.
Shale, roof.			
Coal, sampled	*Lower Kittanning*	1	8
Coal, cannel, sampled	*Lower Kittanning*		2½
Coal, sampled	*Lower Kittanning*		1¼
Coal, shaly, sampled	*Lower Kittanning*		½
Coal, sampled	*Lower Kittanning*	1	8¼
Shale, gray, floor.			

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, pp. 293, 295, 1930.
[2] *Ibid.*, pp. 63-65.

Proximate analysis	As received	Moisture free
Moisture	7.58	0.00
Volatile matter	40.77	44.11
Fixed carbon	43.58	47.16
Ash	8.07	8.73
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	65.88	71.28
Hydrogen	5.58	5.13
Oxygen	15.20	9.16
Nitrogen	1.33	1.44
Sulphur	3.94	4.26
Ash	8.07	8.73
	100.00	100.00

Air drying loss 2.81 per cent

		As received	Moisture free
Heating value	Calories	6,693	7,242
	B. t. u.	12,048	13,036
Fusion of ash	Incipient	2,132°F.	
	Complete	2,374°F.	

The Lower Kittanning clay is the most important clay in Ohio. The clay has not been used to any extent in ceramic manufacture in Holmes County, but in Tuscarawas County, to the east, the clay is widely used for a variety of ware such as refractories, sewer pipe, face brick, conduits, and hollow block.[1] Although no analyses of this clay are available from Holmes County, it apparently has about the same quality as to the east, and could be successfully used for manufacture of similar products.

The Lower Kittanning clay in Holmes County has an average thickness of 5 feet 4 inches and a maximum thickness of 10 feet 6 inches. It is of siliceous nature, in many places becoming more siliceous, or even sandy in the basal part.

HAMDEN MEMBER

The Hamden member is not a steady bed in the Allegheny rocks in Ohio. The bed is lenticular in form and is absent in many places. According to Stout,[2] sediment of marine origin at the Hamden horizon appears in local areas in Columbiana, Mahoning, Stark, Carroll, Tuscarawas, Coshocton, Muskingum, Perry, Hocking, Athens, and Vinton counties. The present study shows that Holmes County can be added to the above list.

The Hamden member lies directly over the Lower Kittanning coal. In Holmes county it is generally a somewhat carbonaceous shale and at many localities contains abundant marine fossils preserved as pyrite. The carbonaceous shale may in some places grade into calcareous clay shale, and at one place a few inches of limestone is known on the horizon. More rarely the Hamden member is ferruginous clay shale, and where this facies of the horizon is evident, ore nodules are commonly present. At few places is a continuous bed of iron ore developed within the member. The undoubted

[1] Stout, W., and others, Coal Formation Clays of Ohio: Geol. Survey Ohio Bull. 26, pp. 305-322, 1923.
[2] Stout, W., Geology of Vinton County: Geol. Survey Ohio Bull. 31, p. 303, 1927.

marine portion of the Hamden is generally confined to the lower few inches of the bed, that part immediately overlying the Lower Kittanning coal. Apparently the marine conditions of sedimentation were very short lived and were succeeded by conditions favorable to the deposition of ferruginous material but seldom favorable to the deposition of real ore. From the evidence at hand we may postulate shallow arms of the sea which transgressed upon the land after the deposition of the Lower Kittanning coal. In such shallow arms of the sea it is natural to expect the deposition of calcareous shale rather than true limestone. The water need not have been deep, because the land at the side would have had such a low relief that very little clastic sediment could have been carried into the basins even though they were rather shallow. The marine conditions were very soon succeeded by brackish water conditions and then probably, at least in some places, by bog and marsh conditions, during which the ferruginous material was deposited.

The Hamden is present in all the townships of Holmes County in which the Lower Kittanning coal is still preserved. Many of the rock sections given to illustrate the Lower Kittanning coal also include the roof shale above, which in some places is fossiliferous and is therefore designated as the Hamden horizon. The outcrop of the bed, of course, occupies the same position as that of the Lower Kittanning coal and its location bed from township to township need not be described in detail.

Paint Township.—Fossiliferous, carbonaceous shale overlies the Lower Kittanning coal at most localities in Paint Township. At a few places the shale is ferruginous, and siderite concretions are common in the shale from 1 to several feet above its base. Excellent fossil collections could be made at many places in this township.

West of Paint Township, in Wayne and Franklin townships of Tuscarawas County, the Hamden horizon is very well displayed in mines and strip pits. In a strip mine of C. A. Wallick in SE¼NE¼SE¼ Sec. 17, Franklin Township, discontinuous lenses of pyritiferous black shale, 50 to 100 feet long and as much as 3 feet in thickness, overlie the Lower Kittanning coal. The shale is richly fossiliferous, brachiopods, pelecypods, and fish teeth being conspicuous.

In Salt Creek, Prairie, Knox, Monroe, and Hardy townships the fossiliferous character of the shale over the Lower Kittanning coal is not conspicuous. Where sandstone immediately overlies the coal, the Hamden is lacking. Where shale is present, weathered material commonly shows no evidences of fossils. Careful examination of fresh material, however, may reveal fossils, as in a drill core from southeastern Hardy Township (55-401, Appendix) in which both macrofossils and microfossils are abundant.

Berlin Township.—Throughout most of western Berlin Township massive sandstone rests directly upon the Lower Kittanning coal, hence the Hamden horizon is present at very few places.

In the mine of Ben Yoder, 100 yards west of the Walnut Creek Township line, three-fourths mile south of the Berlin-Sugar Creek state road, the Hamden is represented by 1 foot of gray clay shale with a few marine fossils. The shale directly overlies the Lower Kittanning coal. This light gray clay shale is a somewhat uncommon facies of the fossiliferous Hamden, as ordinarily the Hamden marine shale is darker, and in most places distinctly carbonaceous.

In the central eastern part of Berlin Township the Hamden fossiliferous shale has an unusual thickness where seen at the local mine of F. J. Brown in E partial Sec. 14, north of the road, one-third mile west of Walnut Creek Township. The shale above the coal is exposed on the hillside above the mine. Although the whole thickness of the shale shown in the section below is fossiliferous, the fossils are more plentiful in the bottom part of the shale. The fossils are preserved as pyrite which weathers rapidly after exposure. This is an excellent place from which to collect Hamden fossils. The section is as follows:

		Ft.	In.
Shale, carbonaceous, fossiliferous, *Hamden*		12	0
Coal, with "dirt" and "sulphur" streaks	*Lower Kittanning,* altitude 1,210 feet	0	4
Coal, good		2	8
Clay, light, plastic		1	0

Walnut Creek Township.—The Hamden horizon has its maximum development and is the most steady in Walnut Creek Township, where it is generally seen as shale forming the roof of most Lower Kittanning coal mines. The shaly facies of this member is particularly well developed over the coal in the area south of Trail. Just north of the village of Walnut Creek the Hamden presents a different appearance from the carbonaceous, shaly facies. Though some carbonaceous shale is present on the horizon, a layer of sideritic ore is present below the carbonaceous shale, and a ferruginous clay shale with abundant sideritic concretions lies over the carbonaceous shale. This facies of the member is well shown along the road from Walnut Creek to Trail, at the north edge of the former village in NW¼ Sec. 20 as follows:

		Ft.	In.
Sandstone		7	0
Clay shale, ferruginous; with ore balls		10	0
Shale, dark, somewhat carbonaceous, iron-stained	*Hamden,* altitude 1,157 feet	5	6
Ore, nodular, dense, hard, calcareous		0	6
Clay shale		1	0
Coal, weathered, *Lower Kittanning*		1	8

The Hamden horizon includes a true limestone at but one known place in Holmes County, in the central southern part of Walnut Creek Township in SE¼NW¼ Sec. 1. The limestone is not in place but many loose blocks crop out at what is believed to be approximately the horizon of the member at an elevation of 1,145 feet. The Lower Kittanning coal is concealed, but the clay is exposed (91-183). The limestone is very hard, almost black, and is apparently somewhat flinty because of the fine grain, but is not actually so. The rock is very fossiliferous, the fossils standing out sharply as lighter calcite in the background of dark limestone. The clay shale above the limestone is somewhat ferruginous.

Clark Township.—The Hamden in Clark Township is not so well developed as a marine member as it is in most places in Walnut Creek Township to the north. At most places in the township the Lower Kittanning coal is overlain by from a few to many feet of ferruginous clay shale, generally bearing many sideritic concretions. This ferruginous clay shale represents, in a general way, the Hamden horizon. As has been mentioned under the discussion of the Lower Kittanning coal in Clark Township, the clay shale makes a very poor roof for the underlying coal.

OAK HILL CLAY AND STRASBURG COAL

In some parts of Ohio a coal and its accompanying clay, the Strasburg and Oak Hill, respectively, lie in a stratigraphic position between the Lower and Middle Kittanning members. The Strasburg coal and Oak Hill clay are present a few miles east of Holmes County in Tuscarawas County, but at only three places in Holmes County was a clay or coal found between the Lower and Middle Kittanning horizons. In SW¼NW½NW¼ Sec. 13, eastern Killbuck Township, a thin clay is exposed above one of the openings to the Lower Kittanning coal in the Quillen mine. The clay is possibly Oak Hill. The strata are as follows:

		Ft.	In.
Soil		3	0
Clay, white, plastic, *Oak Hill?*		1	0
Shale, gray to dark, soft		2	0
Shale, black, hard		3	0
Shale, bone, black, hard		2	0
Coal, bituminous, good	*Lower Kittanning*	1	8
Coal, cannel, shaly in places	*Lower Kittanning*	0	6
Coal, bituminous, good	*Lower Kittanning*	2	0
Clay, plastic		6	0
Shale, gray, grades downward from clay-like shale to siliceous shale		3	0

A layer of impure, sandy clay, lying between the Lower Kittanning coal and the Middle Kittanning clay, was at one time to be seen in SE¼ Sec. 25, in the southeastern part of Clark Township, in one of the early openings in the northwestern part of the quarry of the General Clay

Products Company. The interval here between the two Kittanning horizons is restricted, and possibly the clay referred to as Oak Hill in reality is part of the Middle Kittanning clay. The strata have the following measurements:

	Ft.	In.
Coal, good, *Middle Kittanning,* elevation 1,130 feet	2	10
Clay, light gray to greenish, pyritiferous	1	5
Clay, impure	1	9
Clay, dark gray	0	6
Clay, light, very sandy, almost a sandstone	5	8
Clay, impure, sandy, *Oak Hill?*	8	0
Covered	2	6
Coal, good, *Lower Kittanning*	4	0

At the cemeteries at the county line in the northwestern part of New Bedford, in SE¼SE¼ Sec. 24, Clark Township, poorly exposed clay crops out at about the Middle Kittanning horizon. The clay is overlain by 3 feet of light gray, dense limestone of fresh-water origin which is tentatively correlated as Salem. If the limestone which underlies the Middle Kittanning clay is Salem then the clay below is Oak Hill in age.

Aside from these doubtful exposures, the Oak Hill member was not seen in the county. The Strasburg coal, which is locally found immediately above the Oak Hill clay in parts of Tuscarawas and Stark counties, was not noticed in any outcrop in Holmes County.

SALEM LIMESTONE

An interesting exposure of fresh-water limestone at the base of the Middle Kittanning clay, seen at no other place in Holmes County, is present along the road at the cemeteries at the county line in the northwestern part of New Bedford, in SE¼SE¼ Sec. 24, Clark Township. The section cannot be related to other rock units, but the elevation is appropriate for that of the Middle Kittanning, and the limestone may be a local development of the Salem member.[1] At its type locality the Salem lies immediately below or within a few feet of the Middle Kittanning clay. The limestone in the Holmes County exposure is only slightly nodular, and has the very fine-grained, dense character common to fresh-water limestones. No fossils were observed, but as fossils in fresh-water limestones are commonly small and inconspicuous, they may be present. The section follows:

	Ft.	In.
Covered		
Limestone, gray to white, dense, hard, not very nodular, *Salem?* altitude 1,190 feet	3	0
Clay and covered, *Oak Hill?*	6	0
Shale, sandy	10	0

[1] Stout, W., and Lamborn, R. E., Geology of Columbiana County: Geol. Survey Ohio Bull. 28, p. 146, 1924.

MIDDLE KITTANNING COAL AND CLAY

STRATIGRAPHY AND EXTENT

The Middle Kittanning (No. 6) coal bed is second in importance in Ohio only to the Pittsburgh (No. 8) bed.[1] It is persistent over large areas of the Coal Measures in the State, and is mined in every county in which it crops out. The most important regions in Ohio for the production of coal from this seam are in Tuscarawas, Coshocton, and Muskingum counties, and in the great Hocking Valley field in Perry, Hocking, and Athens counties. In Holmes County the Middle Kittanning is second to the Lower Kittanning in importance as a source of fuel.

The Middle Kittanning or No. 6 coal[2] and clay are the highest beds of any prominence that are at all widespread in Holmes County, being present in Paint, Knox, Monroe, Hardy, Berlin, Walnut Creek, Clark, Mechanic, and Killbuck townships. It is most important as a fuel resource in Clark and Walnut Creek townships. The location of the outcrop of the Middle Kittanning horizon is shown on the geologic map of Holmes County, except in a very few areas where its presence is unknown or concealed. The Middle Kittanning is a more steady bed than the Lower Kittanning, at very few places being wholly absent from it normal stratigraphic position. From 53 measurements throughout Holmes County the average thickness is 2 feet. The greatest seen is 4 feet, and the least, 6 inches. The coal is rarely more than 3 feet thick. The clay beneath the coal has an average thickness of 3 feet 10 inches, computed from 22 measurements. The maximum thickness is 6 feet 6 inches, and the minimum 1 foot.

Over the most of the area of Middle Kittanning coal in Ohio the member is divided into three benches, with clay shale partings between. This structure is not well developed in Holmes County. Indications of such benches are seen in northwestern Clark Township and occasionally in other localities, but throughout most of the county the regularity of benches and partings is not an outstanding characteristic of the stratum. The "upper bench," which may be represented by several inches of bony coal or hard, carbonaceous shale, locally overlies the minable bituminous coal. Below the impure material, the coal at many places is composed of one block. At some localities it has thin pyrite or "dirt" partings which are generally irregular and inconstant.

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[1] Klein, M. S., Annual Coal Report and Non-Metallic Mineral Report with Directories of Reporting Firms, 1946, State of Ohio, Dept. of Industrial Relations, Div. of Labor Statistics, Chart 3, p. 21, 1947.

[2] The Middle Kittanning coal especially of the central and western parts is often called "No. 7" in Holmes County, following an early erroneous identification of the coal beds above the Putnam Hill limestone by M. C. Read in "Report of the Geological Survey of Ohio," Vol. 3, Pt. 1, pp. 543-555, 1878. The error was suspected and the correct identification of the upper coals was surmised, but not insisted upon in 1884 by A. A. Wright, "Report of the Geological Survey of Ohio," Vol. 5, pp. 832, 841, 1884.

In Holmes County the Middle Kittanning coal is, on the average, 43 feet 5 inches above the Lower Kittanning coal, and 83 feet above the Putnam Hill limestone. The Upper Kittanning-Lower Kittaning interval can hardly be described as constant, as it ranges from 18 feet to 80 feet 5 inches. Only one measurement from the Middle Kittanning coal to the overlying Lower Freeport coal was obtained—57 feet 4 inches. The Middle Kittanning is generally overlain by a few feet of carbonaceous or ferruginous shale, which may contain marine fossils. Where the shale is fossiliferous it is identified as the Washingtonville member. Over the few feet of carbonaceous or ferruginous shale is commonly siliceous shale, grading upward into sandy shale. Locally sandstone overlies the coal, but not commonly. Underneath the coal is found the Middle Kittanning clay, which is generally thin, siliceous, and at some places impure. The clay normally grades downward into clay shale, several feet thick, which rests upon the sandstone found at many places between the Lower Kittanning coal and the Middle Kittanning beds.

The general dip of the rocks in this part of Ohio is to the east-southeast, but in Holmes County the regular eastward dip is interrupted in the central part by the Millersburg syncline. The southward component of the dip is more evident over small areas than is the eastward component. In central Paint Township the altitude of the coal is approximately 1,235 feet; 12 miles south, in southeastern Clark Township, the bed is approximately 1,130 feet above sea level. Differences in elevation along east-west lines vary according to the relation of localities to the above mentioned syncline. The position of this coal in the western part of the county in Knox and Monroe townships is of interest, the coal being preserved at the tops of the highest hills in the county.

Paint Township.—The Middle Kittanning coal and clay in Paint Township are found near the top of the "Winesburg Ridge" in the southern part of the township and are present near the top of one or two other hills. The area is therefore small and the thickness is, in general, insufficient for mining, although the thickness at places approaches 1 foot 6 inches.

The coal is somewhat thicker to the east in Wayne Township, Tuscarawas County, than in Paint Township, and has been mined not far from the Holmes County line. Just across the county line in the extreme northwestern corner of Wayne Township, along the ridge road from Winesburg to Beech City, the coal has a thickness of 1 foot 9 inches (11-233, Appendix). One-half mile southeast of the above section, one-half mile east of the county line, and three-fourths mile south of the Greenville Treaty Line, the coal has been mined by G. H. Fellers, where the members have the following character:

		Ft.	In.
Clay shale, gray		2	0
Shale, black, coaly	*Middle Kittanning*	0	2
Coal, good	*Middle Kittanning*	0	2
Coal, bony, with pyrite	*Middle Kittanning*	0	4
Coal, good	*Middle Kittanning*	1	6
Shale, soft, black, carbonaceous with pyrite	*Middle Kittanning*	0	½
Coal, good	*Middle Kittanning*	0	6
Clay, with some iron, plastic, siliceous		6	0

Along the southerly slope of the "Winesburg Ridge" the blossom of the Middle Kittanning coal is evident at various localities, especially in road ditches, at altitudes ranging from 1,220 feet to 1,235 feet. A section measured in the freshly-dug-out ditch of the north-south road, one-half mile southeast of Winesburg, is illustrative of the bed in this part of the township. The data follow:

		Ft.	In.
Clay shale		4	0
Shale, carbonaceous		0	8
Coal, weathered	*Middle Kittanning,* altitude 1,230 feet	0	7
Shale, coaly	*Middle Kittanning,* altitude 1,230 feet	0	1
Coal, weathered	*Middle Kittanning,* altitude 1,230 feet	1	1
Clay, gray, plastic		4	6
Clay shale, gray.			

Along the abandoned north-south road 1 mile northwest of the village of Trail, 8 inches of weathered Middle Kittanning coal is underlain by 4 feet of clay, a part of which is poorly exposed. The Middle Kittanning coal is here 40 feet above the base of the underlying Putnam Hill limestone and 57 feet 4 inches below the Lower Freeport coal which crops out along the road farther to the north (6-205, Appendix).

The Middle Kittanning members are well exposed along the state road near Easley School in the southwestern corner of Paint Township at an elevation of approximately 1,225 feet, where the coal is 4 inches thick and the underlying clay 3 feet 8 inches (4-207).

One-quarter mile southeast of the state road from Berlin to Winesburg, at the Paint-Walnut Creek township line, Mr. J. W. Dowalter reports that in drilling on the farm of Samuel Troyer, in various drill holes he encountered Middle Kittanning coal which ranges in thickness from 6 inches to 1 foot 6 inches, underlain by about 1 foot of clay. The coal is overlain by as much as 10 feet of sandstone. Mr. Dowalter reports that the interval to the Lower Kittanning coal, which is mined for local use in a ravine on this farm, is 32 feet (5-227).

The Middle Kittanning members undoubtedly underlie the high north-south ridge which is about 1½ miles west of the village of Winesburg. The coal does not crop out at any place along this ridge because of the heavy covering of glacial drift, but indications of clay at the horizon of the Middle Kittanning are evident at two or three places along the ridge. The most noticeable of these is along the Winesburg-Mt. Hope road, about 1 mile west of Winesburg, 53 feet above an abandoned mine in the Lower Kittanning coal (8-206).

Salt Creek Township.—The normal rise of the strata has carried the horizon of the Middle Kittanning members above the present surface throughout most or all of Salt Creek Township. At no place in this township were the Middle Kittanning members observed, although they may be present beneath the drift at one or two of the higher places in the township.

Knox Township.—Small areas of the Middle Kittanning members are preserved in the eastern part of Knox Township. Three of these are at the top of the highest parts of Bell Ridge in the central eastern part of the township and another underlies the high knob, which is the highest land in Holmes County, 1½ miles south of Nashville. The coal at each of these localities is of minable thickness and most of it has been removed by underground mining or by stripping.

The Middle Kittanning coal has been mined by drifting into the hillside and by stripping on the farm of Wallace Bell 2⅛ miles south of Ripley Township and one-half mile west of Monroe Township. The coal is of good quality and well liked for domestic use. The clay underlying the coal is siliceous and of poor quality. The base of the coal is 60 feet and 2 inches above the base of the underlying Putnam Hill limestone, which is exposed in a ravine to the west (26-324). The interval between the Putnam Hill and the Middle Kittanning coal is occupied by a coarse sandstone which replaces the Lower Kittanning members. A section in the Bell stripping follows:

		Ft.	In.
Clay shale, slightly ferruginous		6	0
Shale, hard, carbonaceous		1	6
Coal, bony	*Middle Kittanning,* altitude 1,340 feet	0	7
Coal, good		3	6
Clay, siliceous		4	0

South of the Bell farm, 3¼ miles south of Ripley Township, one-half mile west of Monroe Township, and one-fourth mile south of Bell Ridge School, a small area of the Middle Kittanning is present. Much of this coal has been removed by drift mining from an opening on the farm of Charles Reed just west of the road. As there is not more than 15 feet of cover the coal is stained along the joints by iron compounds carried by circulating ground water. A section measured in the entry of this mine follows:

		Ft.	In.
Shale, gray		2	0
Shale, hard, carbonaceous		0	7
Coal, bony	Middle Kittanning, altitude 1,330 feet	0	3
Coal, good		1	6
Shale, dark, soft, coaly		0	¼
Coal, good		0	7
Shale, coaly, soft		0	¼
Coal, good		1	0
Clay, light gray, plastic, siliceous		4	0

One and one-half miles south of the village of Nashville the Middle Kittanning members underlie the high knob which rises to a little over 1,400 feet elevation and which is the highest land in Holmes County. Several old entries are present east of the north-south road and for many years a little mining community was in existence here. Most of the coal remaining after underground mining has recently been removed by stripping. This highest coal, which is Middle Kittanning, was called the "Number Seven" by the local miners. The coal in the small mines is reported by Mr. W. E. Faler to have been from 3 to 3½ feet thick. He reports that the coal is in a single bench with no partings. He further reports that the roof is similar to that of the Middle Kittanning coal on Bell Ridge, but is less strong so that powder could not be used and the coal had to be pried out with bars. The coal rests on a clay floor. The quality of this upper coal is said not to be as good as the Lower Kittanning coal which was mined on the south side of the knob. In 1942 and 1943 most of the coal still remaining in the knob was removed by stripping. Mr. Charles Atha who superintended the stripping operation reports that the coal was generally about 4 feet. The coal is overlain by dark shale which is in turn overlain disconformably by sandstone. In some places the sandstone is directly on the coal and has replaced the upper part. A section measured at the east end of the stripping is as follows (see also 25-396, Appendix):

		Ft.	In.
Till, composed mostly of sandstone fragments		5	0
Sandstone, coarse, irregular; at other places extends downward to coal		4	0
Shale, black, carbonaceous		8	0
Coal, good	Middle Kittanning	0	7
Shale, pyritiferous		0	0½
Coal, good		1	7
Shale, pyritiferous		0	0½
Coal, good		1	5
Clay, plastic		2	0

Monroe Township.—The Middle Kittanning horizon is retained in Monroe Township only near the top of the north-south ridge in the extreme western part of the township, about 1 mile east of the Knox Township boundary. Most of the coal of minable thickness has been removed. The coal was formerly mined from very close to the top of the hill, which reaches an elevation in excess of 1,320 feet on the T. M. Allison farm at the road fork 2 miles south of Ripley Township and one-half mile east of Knox Township. Mr. Allison reports that the coal extracted was "peacock" coal and reached a maximum thickness of 4 feet, and that about 2 feet of siliceous clay was found underneath the coal. The roof is reported to have been a somewhat hard, carbonaceous shale. A maximum thickness of 20 feet of shale was between the top of the coal and the surface of the hill. The elevation of the coal here is approximately 1,310 feet. In 1944 the unmined part of this coal was removed by stripping. To the northwest of the Allison farm some Middle Kittanning coal has been stripped, and it was discovered that the coal became thinner northward.

Discontinuous patches of the Middle Kittanning may be retained to the south along the top of the ridge. If so, the elevation of the bed decreases to the south. Just north of the road fork, the elevation of which is 1,280 feet, three-fourths mile north of the Richland-Monroe township line and three-fourths mile east of the Knox-Monroe line, the Middle Kittanning coal horizon may be occupied by shale, as shown by the following section:

	Ft.	In.
Shale, sandy, with ore balls	2	0
Shale, dark, carbonaceous, sandy, and micaceous, *Middle Kittanning* horizon (?), altitude 1,280 feet	2	1
Shale, very impure, sandy, and ferruginous; slightly clay-like	0	5
Sandstone, massive	18	0

Hardy Township.—With the exception of a small area of Middle Kittanning coal which reaches minable thickness in the southwestern corner of Hardy Township, the members under discussion are of little importance in this township. Because of the depressing of the strata along the axis of the north-south syncline which passes through Millersburg, younger beds are preserved in the region of this synclinal axis than remain either to the east or immediately to the west. The Middle Kittanning coal and clay are found in the southern part of the township on both sides of Killbuck Creek. The coal in the southwestern corner of the township is of minable thickness; that in the southeastern corner is neither of minable thickness nor of good quality.

The Middle Kittanning coal has been mined from several openings in the southwestern corner of Hardy Township, where the coal underlies the northeast-southwest ridge in an area about one-fourth mile wide and 1 mile long. The northwest boundary of the area is not known exactly, as it is obscured by glacial drift. The coal is of good quality and is prized for local use, much of it being shipped by truck to Millersburg 3 miles away.

The coal ranges from 3 to 4 feet in thickness. In the mine of the Donald Coal Company, three-fourths mile east of Monroe Township and three-eighths mile north of Killbuck Township, there is, in most places in the mine, a layer of cannel coal at the top of the bituminous coal. At some places the cannel coal is much thicker than at other places. Details of the coal where only a small proportion of cannel is present and the relation to lower members are shown in 54-290, Appendix. The maximum thickness of the cannel coal is 1 foot 8 inches, as shown in the following section which was secured about 100 yards from the mine entry:

		Ft.	In.
"Slate"		2	0
Coal, cannel, good	Middle Kittanning	1	8
Coal, dirty and bony	Middle Kittanning	0	9
Coal, block	Middle Kittanning	1	5
Clay.			

At the Hardy-Berlin township line along the Millersburg-Berlin state road in SE¼ Sec. 14, a few loose pieces of the Middle Kittanning coal are present at the top of the hill at an elevation of approximately 1,235 feet, but the clay was not seen (60-66).

A very small area of the Middle Kittanning coal underlies the top of the hill across which the east-west road runs in central Sec. 24, in the southeastern corner of Hardy Township. Along the road in NE¼SW¼ Sec. 24, 1 foot 6 inches of weathered Middle Kittanning coal, underlain by 2 feet 4 inches of clay, crops out 80 feet above the Lower Kittanning coal which is mined south of the road (62-42).

Berlin Township.—The Middle Kittanning members are present in the central and eastern parts of Berlin Township. They were not observed in the western part of the township. Little is known of the Middle Kittanning members in the northeastern part northwest of Indian Creek, because they are generally concealed by drift. At an outcrop north of North Bunker Hill School the following beds are exposed along a road between SW¼NW¼ Sec. 4 and SE¼NE¼ Sec. 5:

		Ft.	In.
Crossroad, elevation 1,273 feet			
Shale, siliceous to sandy		23	4
Shale, siliceous to clayey		3	0
Shale, dark, carbonaceous		2	0
Coal, somewhat bony	Middle Kittanning	0	7
Coal, good	Middle Kittanning	1	1
Clay, gray, plastic, siliceous		5	0
Sandstone, white, with some clay-bonding		8	0

The Middle Kittanning members are exposed along the east-west road at the top of the hill in central Sec. 7, where the coal is 11 inches in thickness and the underlying clay 2 feet (65-225). The coal thickens to the south, where it crops out along the north-south road one-half mile south of the South Bunker Hill School in SW¼SW¼ partial Sec. 14 as follows:

	Ft.	In.
Shale, siliceous	30	0
Coal, *Middle Kittanning,* elevation 1,260 feet	1	7
Clay, impure	3	0

Less than 1 mile south of the above exposure, the coal is mined in a small way from an opening just north of the Berlin-Sugar Creek state road, 1¼ miles southeast of the state road fork in Berlin village. The coal is of good quality and the roof is very firm. The coal in the mine and the strata above, exposed along the road, have the following measurements:

	Ft.	In.
Sandstone, shaly	33	0
Shale, sandy	32	6
Shale, dark, gray	6	0
Shale, dark, soft	0	6
Coal, good, *Middle Kittanning,* altitude 1,225 feet	2	4
Clay.		

In the vicinity of Berlin the strata rise rapidly to the west so that only very small areas of the Middle Kittanning members underlie the high hill on which the village is located and the hill one-half mile south. The horizon of the Middle Kittanning coal and clay is retained near the tops of these hills but no clear sections crop out.

Near Miller School in the southeastern part of the township the Middle Kittanning members are exposed along the ridge at an elevation of approximately 1,235 feet, where the weathered coal is 2 feet 9 inches in thickness, and is underlain by 3 feet of clay, three-fourths mile west of Walnut Creek Township and 1⅜ miles north of Clark Township. The coal thins to the east, as shown by the following measurements secured along the road, one-eighth mile south of the Berlin-Walnut Creek road and one-fourth mile west of the Berlin-Walnut Creek township line:

Bench mark, elevation 1,259 feet.	Ft.	In.
Shale	32	0
Coal blossom, *Middle Kittanning*	1	0
Sandstone, shale; and covered	48	0
Coal, old mine, *Lower Kittanning*	4	0
Clay shale, sandy; and covered	10	0

Less than a mile south of the above outcrop, Mr. Ben Yoder reports that 1 foot of Middle Kittanning coal was found when drilling test holes to the Lower Kittanning coal.

Walnut Creek Township.—The area of the Middle Kittanning coal and clay is small in Walnut Creek Township, but is well distributed throughout the whole township. As mentioned previously, the topography consists of long, narrow, somewhat flat-topped ridges, with very few isolated hills. It is near the tops of these ridges that the Middle Kittanning horizon is found.

A few of the higher portions of the ridge in the northeastern corner of the township rise high enough to retain the Middle Kittanning horizon. The areas here are very small and the coal is thin. Along the bank of the east-west road, 1 mile south-southeast of Trail, the following beds are exposed:

	Ft.	In.
Shale, sandy, slightly ferruginous	10	0
Coal blossom, *Middle Kittanning,* elevation 1,240 feet	1	2
Clay and covered	5	0

In the northwestern part of Walnut Creek Township the Middle Kittanning coal is of variable thickness but at no place is it much more than 1 foot. One foot 3 inches of weathered coal crops out just west of the 1,281-foot crossroad at the east margin of partial Sec. 8, at an elevation of 1,257 feet (81-224, Appendix). It is underlain by 1 foot 8 inches of gray, siliceous clay and overlain by a sandy shale. The Middle Kittanning coal and clay underlie in western Walnut Creek Township the ridge along which runs the east-west road between the villages of Berlin and Walnut Creek. One-quarter mile south of the road, in N partial Sec. 18, the Middle Kittanning coal is approximately 1 foot thick and is underlain by 3 feet of siliceous clay at an elevation of 1,215 feet (82-97). In the extreme southwestern corner of Walnut Creek Township the thickness of the Middle Kittanning coal, where seen, ranges from 1 foot 3 inches to 1 foot 6 inches.

In the southeastern part of Walnut Creek Township, southeast of Walnut Creek Valley, the Middle Kittanning coal is very steady. The coal was formerly mined on either side of the state road from Walnut Creek to Sugar Creek in NW¼NW¼ Sec. 5 south-southeast of Walnut Creek village, where it is reported to have been 1 foot 9 inches thick and of good quality (92-190). North of Cigar Ridge School, in E Sec. 25 and W and N Sec. 24, several openings to the Middle Kittanning coal show the coal to be 2 feet 10 inches in thickness (93-134). The fossiliferous, carbonaceous Washingtonville shale forms an excellent roof, standing long after a mine is abandoned. In this part of the township the roof over the Middle Kittanning coal is superior to that over the Lower Kittanning coal, so that the upper coal is mined in preference to the lower coal, although the Lower Kittanning coal in this region reaches minable thickness and is of good quality. In NW Sec. 4 the Middle Kittanning coal is similar to that to the northwest in Sec. 25. At the local mine of A. D. Yoder, 200 yards south of the state road and one-fourth mile southeast of the Cigar-Ridge-School crossroad, 2 feet 8 inches of coal is visible in the entry. It is reported that on the north side of the ridge the coal is as much as 3½ feet in thickness. The Lower Kittanning coal is reported to lie approximately 35 feet below the Middle Kittanning horizon.

Clark Township.—Both the largest area and the largest minable area of Middle Kittanning coal in any township in Holmes County are found in Clark Township. The elevation of the beds in this township is lower than in the townships to the west and north because of the southward and eastward dip of the strata. The clay underlying the coal also seems to be of greater thickness in this township than elsewhere in Holmes County. The roof over the Middle Kittanning coal is of excellent quality, in some places being so strong and hard that mining can be carried on by setting very few posts.

In the northeastern corner of the township, in NE¼SE¼SE¼ Sec. 5, the Middle Kittanning coal has been mined by Edward and Hiram Klotz, where the structure of the coal is as follows:

		Ft.	In.
Shale, hard, carbonaceous, fossiliferous, *Washingtonville*		0	6
Coal, fair	*Middle Kittanning*	0	6
Coal and partings interbedded	*Middle Kittanning*	0	2
Coal, good	*Middle Kittanning*	0	7
Parting, soft	*Middle Kittanning*	0	¼
Coal, good	*Middle Kittanning*	0	7
Parting, soft	*Middle Kittanning*	0	¼
Coal, good	*Middle Kittanning*	1	2
Clay, gray, soft		2	0

The ridge between the South Fork of Sugar Creek and Troyer Valley Creek in NW Sec. 14, N Sec. 15, SW Sec. 6, S and W Sec. 10, and Sec. 9, is underlain near the top by Middle Kittanning coal, which is from 2 to 3 feet in thickness in many places. The elevation of the coal ranges from 1,140 feet at the southeastern end of this ridge to 1,180 feet northwest of Farmerstown. At the southeastern end of this ridge the blossom of the Middle Kittanning coal crops out along the road in NW¼NW¼ Sec. 14 as follows:

	Ft.	In.
Shale, yellowish	22	8
Shale, hard, carbonaceous	0	8
Coal, weathered, *Middle Kittanning,* altitude 1,140 feet	1	6
Clay, and covered	8	0
Sandstone, shaly	20	0

In N Sec. 15 and S Sec. 6 the coal is exposed at an elevation of approximately 1,140 feet but no clear sections were seen for measurement. In S Sec. 10 the coal has been mined and its quality is said to be satisfactory. In the local mine of A. C. C. Slabaugh in SW¼SE¼ Sec. 10 a thickness of 32 inches is reported. The bed of coal seems to be a single block with no parting, as shown by the following section secured in the local mine of Dick Harmon west of the road in SE¼SW¼ Sec. 10:

	Ft.	In.
Shale, siliceous	20	0
Shale, siliceous to clay-like	51	0
Clay shale, gray	3	0
Shale, black, hard, bone	1	1
Coal, good, *Middle Kittanning,* altitude 1,170 feet	2	7
Clay	3	0

Under the village of Farmerstown the area of Middle Kittanning coal preserved is small and the coal is rather unsteady. Less than one-half mile south of Farmerstown the Middle Kittanning horizon appears to be occupied by a sandstone (96-164) but north of Farmerstown the coal remains. The relationship of the Middle Kittanning horizon to the underlying Lower Kittanning is shown by the following measurements secured along the road just north of Farmerstown in NE¼NE¼ Sec. 12:

	Ft.	In.
Clay shale, weathered	8	0
Coal, fair, weathered, *Middle Kittanning,* altitude 1,150 feet	2	6
Clay, light; and covered	3	0
Sandstone and covered	14	0
Sandstone, light buff to yellow, thin-bedded	17	0
Clay and covered, *Lower Kittanning*	3	0

In central Sec. 9, three-fourths mile northwest of Farmerstown, the strata which crop out along the road are as follows:

	Ft.	In.
Shale, sandy, ferruginous	10	0
Shale, clay-like, somewhat ferruginous at base	5	0
Coal, weathered, *Middle Kittanning,* altitude 1,185 feet	1	9
Clay, siliceous, plastic, light	4	0
Sandstone, shaly, white	10	0

Farther west of Farmerstown the Middle Kittanning coal has a thickness of 2 feet or more. Along the Charm-Farmerstown road the coal crops out at an elevation of 1,190 feet with a thickness of 2 feet 1 inch (99-170) in NW¼SW¼ Sec. 8. Five-eighths mile west-southwest, in SW¼SE¼ Sec. 7, the coal ranges from 2½ to 3 feet in thickness and has been mined in a small way.

Three-fourths mile east of Charm the Middle Kittanning members are exposed as follows just south of the 1,232-foot road fork in SE¼SE¼ Sec. 4 (see also 100-117, Appendix):

	Ft.	In.
Sandstone, iron-stained	15	0
Shale, ferruginous	12	0
Coal, blossom, *Middle Kittanning,* altitude 1,205 feet	1	10
Clay, light, plastic, siliceous	6	6
Sandstone, very shaly	10	0

West and southwest of Charm the Middle Kittanning coal has a thickness of 2 feet or more. At the top of the small hill in NW¼NE¼ Sec. 6 the coal is 2 feet 2 inches (103-88). The north-south ridge in the central and southern parts of Sec. 6 retains a considerable area of Middle Kittanning coal. The coal and the associated beds are well shown in an abandoned mine just east of the road in NE¼SW¼ Sec. 6 where the following data were secured:

	Ft.	In.
Shale, grayish, iron-stained	30	0
Clay shale, ferruginous, marine fossils, *Washingtonville*	0	5
Shale, carbonaceous — *Middle Kittanning,* altitude 1,225 feet	0	5
Coal, good — *Middle Kittanning,* altitude 1,225 feet	2	2

In the southern part of Sec. 6 the clay underlying the coal is much reduced in thickness. The various divisions of the coal beds and the clay were shown in a mine on the farm of E. D. Kurtz in SE¼SW¼ Sec. 6 as follows:

	Ft.	In.
Shale, bone.		
Shale, hard bone — *Middle Kittanning*	0	11
Coal, good (with thin dirt parting) — *Middle Kittanning*	1	6
Pyrite, soft; and shale, dark — *Middle Kittanning*	0	¾
Coal, good — *Middle Kittanning*	1	4
Shale, bone, variable — *Middle Kittanning*	0	2
Clay, variable	0	4
"Slate" (reported)	1	6
Covered and sandstone	40	0
Coal, *Lower Kittanning*	0	4
Clay, light, plastic	5	0

Middle Kittanning coal having a thickness of as much as 6 feet has been reported from E Sec. 15, but such a thickness must be over a small area only. Although no outcrops were seen in NW Sec. 14, a considerable body of Middle Kittanning coal may be present. The following beds were measured in a ditch along the road in SE¼SE¼NE¼ Sec. 15:

	Ft.	In.
Clay to siliceous shale; lower 6 inches with ore balls	15	0
Coal, good, *Middle Kittanning,* altitude 1,220 feet	2	8
Clay, gray, plastic, siliceous, (bottom not seen)	5	6

The coal of fair thickness extends to the south where, south of Yoder School, in SW¼NW¼ Sec. 17, weathered Middle Kittanning 1 foot 10 inches in thickness, underlain by several feet of siliceous, plastic clay, crops out along the east-west road at an elevation of 1,200 feet (108-185). In NE¼NE¼ Sec. 17 the coal is somewhat reduced in thickness, as shown by the following section measured along the road:

	Ft.	In.
Shale, sandy	13	0
Clay shale, grading upward to siliceous shale; iron knots present	12	0
Coal, weathered, *Middle Kittanning,* altitude 1,180 feet	1	6
Clay, gray, plastic	2	0

The Middle Kittanning coal was formerly mined in the vicinity of Knob School from NE¼NE¼ Sec. 25, SE¼SE¼ Sec. 16, SW¼SW¼ Sec. 17, and NW¼NW¼ Sec. 24. The mines in this locality have all been abandoned, and it is probable that most of the coal has been removed. The coal was about 2 feet 6 inches in thickness and was overlain by 10 feet of shale which, in turn, was covered by 20 feet of shaly sandstone. Just north of the village of New Bedford the Middle Kittanning coal is due, but it seems to be replaced by a massive sandstone which crops out boldly along the road. The coal reappears in the east edge of New Bedford at the county line.

In the central southern part of Clark Township, south of the South Fork of Sugar Creek, discontinuous and relatively small areas of Middle Kittanning coal are present. The coal in this part of the township is thinner than that to the east in the southeastern corner of the township.

At the cross-road one-half mile north of the county line, on the line between secs. 21 and 22, the horizon of the Middle Kittanning is marked by several feet of clay, the approximate top of which, and therefore the bottom of the Middle Kittanning coal, is 31 feet 6 inches above the base of the underlying Lower Kittanning coal. One-half mile to the east, in central Sec. 21, 10 inches of weathered coal is exposed along the road, underlain by several feet of clay, the exact thickness of which could not be determined. Here it is seen that the interval from the Middle Kittanning coal to the Lower Kittanning coal has thinned rapidly to the east, being but 26 feet 5 inches. It is possible that the thickness of the Middle Kittanning coal under cover is somewhat greater than that exposed along the road.

In the southeastern corner of Clark Township the Middle Kittanning coal is of good quality, of fair thickness, has a strong roof, and several local mines have operated in the bed. The Middle Kittanning horizon underlies SE¼ Sec. 25 and much of Sec. 24. At the shale and clay pit of the General Clay Products Company, one-half mile northeast of Baltic, in SE¼ Sec. 25, the Middle Kittanning coal ranges from less than 3 feet to a little more than 3 feet at different places within the pit (117-152). The underlying clay, generally siliceous to sandy, ranges from about 2 feet to as much as 5 feet.

The Middle Kittanning coal in SW¼SW¼ Sec. 24 is about 2 feet 6 inches in thickness, as shown in the mine of Young & Company where a sample was taken for analysis. (See under "Economic Value.") The roof is so hard and so strong that few or no posts are needed in the mine, abandoned rooms remaining with the roof unfallen for a long period.

Middle Kittanning coal has been mined from secs. 4 and 5 of Bucks Township, Tuscarawas County, which adjoins Clark Township, Holmes County, on the south. In these sections of Bucks Township the Middle

Kittanning coal is apparently not as thick as it is to the north in Clark Township, Holmes County. The interval from the Middle Kittanning coal to the underlying Lower Kittanning coal is 18 feet as measured along the road southeast from the school in Baltic (118-146).

In the southeastern corner of Clark Township the interval between the Middle Kittanning coal and the underlying Lower Kittanning coal is abnormally short. As measured in the quarry of the General Clay Products Company in SE¼ Sec. 25, this interval ranges from 23 feet 6 inches to 18 feet. It is also 18 feet, a little less than a mile to the south in Sec. 5, Bucks Township, Tuscarawas County (118-146). The interval is gradually shortened from more than 55 feet in the southwestern part of the township to about one-third this distance in the southeastern portion.

Mechanic Township.—The Middle Kittanning horizon in Mechanic Township is retained in only a very few small and unimportant areas in the northeastern and northwestern portions, and in one area larger than the others, but still small and unimportant, along the central western boundary of the township. That any horizon this high stratigraphically is retained at all is due to the reverse west dip into the syncline, the axis of which more or less coincides with the west line of the township, which has depressed the strata and thus preserved the Middle Kittanning horizon at the tops of a few high hills. It is interesting to note that the elevation of the Middle Kittanning coal along the Killbuck-Mechanic township line is the same as the elevation of the horizon in the central part of Clark Township more than 8 miles to the east.

In the northeastern part of the township the bed remains near the top of the hill in SW¼SE¼NE¼ Sec. 2, where the Middle Kittanning coal[1] is overlain by coaly shale, as shown by the following section measured along the north-south road:

		Ft.	In.
Shale		3	0
Shale, coaly	*Middle Kittanning,* altitude 1,225 feet	2	6
Shale, gray		1	2
Coal, weathered		4	0

In the northern part of Sec. 2 and in the adjoining portion of Berlin Township to the north, near the top of the high ridge upon which the hamlet of Saltillo is built, and along this ridge to the southwest of Saltillo, the Middle Kittanning horizon is absent. The massive sandstone which lies over the Lower Kittanning coal is the highest rock unit present. In the northwestern corner of the township, in SE¼ Sec. 1, a coal blossom thought to be Middle Kittanning crops out in the bank of a road at an elevation of approximately 1,185 feet.

[1] This small area is not shown on the geologic map.

In SE¼NE¼ Sec. 10 a weathered outcrop marks the position of the Middle Kittanning horizon where the following beds were measured along the road:

	Ft.	In.
Shale, siliceous; with iron nodules	8	0
Clay shale, weathered; lower part slightly iron-stained	1	6
Coal, weathered, *Middle Kittanning*, altitude 1,170 feet	1	5
Clay, light, siliceous	4	0

The largest area of the Middle Kittanning in Mechanic Township, in secs. 9 and 12, is part of an area extending into eastern Killbuck Township. In this part of the township the Middle Kittanning horizon is about 100 feet above the Putnam Hill limestone. In SW¼SW¼ Sec. 9 a 2-foot blossom of the Middle Kittanning, overlain by 32 feet of shale, crops out along the road at an elevation of approximately 1,185 feet. A small amount of the Middle Kittanning coal is believed to be present in NW¼ Sec. 12 but no clear section could be uncovered for measurement.

Killbuck Township.—Strata of Middle Kittanning age are represented in Killbuck Township by a small area in Sec. 13 and probably in SE¼ Sec. 8, in the central eastern part of the township. Elsewhere the surface has been eroded below this horizon. The Middle Kittanning members crop out at several places along the road which runs along the top of the ridge in N. Sec. 13. Because the coal is so close to the surface its full thickness is not obtainable at any place. The clay is several feet in thickness and is siliceous. It is reported that in the past century the clay was used in a small way by local potters for the making of crocks, jugs, and other earthenware. The clay for this use is said to have come from near the crossroads in NE¼NW¼ Sec. 13. The relation of the Middle Kittanning to the Lower Kittanning horizon in Sec. 13 is shown in 149-32, Appendix.

ECONOMIC VALUE

As may be noted from the outcrop of the Middle Kittanning coal shown on the geologic map of Holmes County, this bed is most extensive in the eastern part of the county. It has its greatest thickness in Walnut Creek and Clark townships. Smaller areas are found in other townships, as already described. The bed in Walnut Creek and Clark townships is regular and steady, but it rarely exceeds 3½ feet in thickness.

The Middle Kittanning coal has an excellent roof of tough shale at most places. The floor is clay, commonly siliceous and hard.

The Middle Kittanning coal is bright, banded, bituminous coal. Only rarely, as in southwestern Hardy Township, are layers of cannel coal included in the bed. Regular partings, which are so characteristic of the bed in other parts of Ohio, are not so well exhibited in Holmes County, where the partings generally cannot be followed long distances.

The ash and sulphur in the Middle Kittanning coal are low to moderate, especially if care is taken in mining. The heating value is good, being about average for the bed in Ohio. Much of it exceeds the Lower Kittanning coal in calorific value. The following analyses show the character of the coal from two localities:[1]

Sample of Middle Kittanning coal taken in 1928 by W. S. Glock and L. O. Naffziger from mine of Young & Co., in southwest part of Section 24, German [Clark] Township, Holmes County. Analysis by D. J Demorest.

		Ft.	In.
Shale, carbonaceous, roof.			
Coal, bony, rejected	*Middle Kittanning*	0	1¼
Coal, sampled	*Middle Kittanning*	2	4
Clay, gray, siliceous		0	7
Clay, light, plastic, floor.			

Proximate analysis

		As received	Moisture free
Moisture		5.84	0.00
Volatile matter		40.29	42.79
Fixed carbon		48.60	51.61
Ash		5.27	5.60
		100.00	100.00
Sulphur		2.65	2.82
Air drying loss 1.46 per cent			
Heating value	Calories	7,093	7,533
	B. t. u.	12,767	13,559
Fusion of ash	Incipient	2,152°F.	
	Complete	2,402°F.	

Sample of Middle Kittanning coal cut in 1902 by B. A. Eisenlohr from mine of Michael Zahnder, one mile northwest of Shanesville, northeast corner Sec. 4, south, Walnut Creek Township, Holmes County. Sample 14 by 7 inches. Analysis by Lord and Somermeier.

	Ft.	In.
Shale, siliceous.		
Coal, sampled, *Middle Kittanning*	2	6
Clay, plastic.		

Proximate analysis

	As received	Moisture free
Moisture	7.31	0.00
Volatile matter	34.92	37.68
Fixed carbon	53.56	57.78
Ash	4.21	4.54
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	70.62	76.19
Hydrogen	5.42	4.97
Oxygen	17.31	11.66
Nitrogen	1.44	1.56
Sulphur	1.00	1.08
Ash	4.21	4.54
	100.00	100.00

[1] Bownocker, J. A., and Dean, E. S., Analyses of the Coals of Ohio: Geol. Survey Ohio Bull. 34, pp. 90-91, 1930.

		As received	Moisture free
Heating value	Calories	6,952	7,500
	B. t. u.	12,514	13,500

The Middle Kittanning clay is generally siliceous to sandy and locally impure in Holmes County. It does not compare with the Brookville or Lower Kittanning clays in thickness or quality. At a few places the Middle Kittanning clay may be of sufficient thickness and quality for certain ceramic uses.

WASHINGTONVILLE MEMBER

Overlying the Middle Kittanning coal bed in much of Ohio is a fossiliferous, generally carbonaceous, and in many places ferruginous, shale which is marine in origin. It is called the Washingtonville member from exposures near that village in Columbiana County.[1] This member is present over the Middle Kittanning coal at many localities in Holmes County.

The Washingtonville member is dark to black, carbonaceous, tough shale. At places it is somewhat ferruginous. It contains fossils of marine invertebrates, locally in large numbers. The fossiliferous part of the member ranges from a few inches to several feet in thickness, which passes upward to nonfossiliferous, dark shale, and thence generally to medium-grained or sandy, gray shale.

The shale over the Middle Kittanning coal, whether fossiliferous or not, usually makes a very good roof. In many Middle Kittanning coal mines few timbers are needed, and the roof remains up for a considerable length of time after a mine is abandoned or shut down. This is in contrast to the roof over the Lower Kittanning coal which is commonly of much less strength.

The thickness and character of the shale over the Middle Kittanning coal are shown in almost all rock sections in which that coal appears, both in the detailed township descriptions of the coal and in the larger sections assembled in the Appendix, to which reference may be made. The fossiliferous nature of the shale seems best developed in Berlin, Walnut Creek, and Clark townships, but this character is also to be seen at places in the other townships in which the Middle Kittanning coal is present. The following section cropping out along the state road 1 mile southeast of Berlin, Berlin Township, is illustrative of the scores of similar sections exposed in the eastern and southeastern parts of Holmes County:

	Ft.	In.
Shale, gray, sandy	57	0
Shale, dark, carbonaceous	5	0
Shale, dark, carbonaceous, fossiliferous, *Washingtonville*	0	6

[1] Stout, W., and Lamborn, R. E., Geology of Columbiana County: Geol. Survey Ohio Bull. 28, p. 176, 1924.

			Ft.	In.
Coal, slightly weathered	*Middle Kittanning*	......	2	2½
Shale, coaly	altitude 1,240 feet	......	0	1
Clay, gray, plastic			4	6
Sandstone, clay-bonded, ganister			1	0

LOWER FREEPORT SANDSTONE

The Lower Freeport is the name given to the sandstone which occurs at many places in Ohio between the Middle Kittanning and Lower Freeport coals. At some places it coalesces with the Upper Freeport sandstone, the combined sandstone unit replacing the Lower Freeport coal. In Holmes County the Lower Freeport sandstone is not a conspicuous unit, both because its horizon is retained on only the highest hills and ridges and because of general lack of sandy deposits at the horizon. Where sandstone is present, it does not commonly extend downward to the Middle Kittanning coal, so that the coal is not affected by it.

In Knox Township, 5 to 20 feet of Lower Freeport sandstone lies over the Middle Kittanning coal in the strip mine on the knob 1½ miles south of Nashville. The base of the sandstone is very irregular, having a relief in a distance of 100 feet of 10 feet or more. Some of the deeper channels extend into, or through, the coal.

Shale, with a few layers of shaly sandstone, is present at the horizon of the Lower Freeport sandstone in a few of the highest hilltops in southeastern Berlin Township. No prominent massive sandstone was noted, however. Along the state road 1½ miles southeast of Berlin, shaly sandstone above the Middle Kittanning coal is identified as Lower Freeport sandstone.

The Lower Freeport sandstone is not developed in Walnut Creek Township, except possibly to a slight extent in the southeastern part. Here, although shale overlies the Middle Kittanning coal for as much as 40 feet, a few feet of sandstone appears over the shale.

The Lower Freeport sandstone is not developed in eastern Clark Township, where 50 feet or more of shale overlies the Middle Kittanning coal. A little shaly sandstone is present southeast of Baltic, in Tuscarawas County, about 50 feet above the Middle Kittanning horizon, but it is not well developed. In the western part of Clark Township a few feet of sandstone is preserved at the tops of the higher knobs in sections 4 and 8, twenty feet or more above the Middle Kittanning coal.

The most prominent outcrop of the Lower Freeport sandstone seen in the county is in NE¼ Sec. 15 and NW¼ Sec. 14, Clark Township, 1⅜ miles south of Charm, where several prominent knobs rise to elevations of from 1,280 to 1,300 feet, about 80 feet higher than the Middle Kittanning coal. The full thickness of the sandstone is not exposed, but at least 22 feet of sandstone is exposed on the knob in NE¼ Sec. 15. The stone is massive, coarse-grained, weathered buff, tending to disintegrate readily upon weathering. It is probably blue gray under cover where unweathered. It is composed mainly of subangular quartz grains, a few plates of muscovite, and a little clay.

No well-developed sandstone is present above the Middle Kittanning coal in those few localities in Mechanic Township where that coal horizon remains uneroded. In the central western part of the township occurs the greatest thickness of strata above the coal, amounting to 32 feet, but the material is shale, rather than sandstone.

The lack of firm cementing material and the restricted size and irregular character of the deposits of Lower Freeport sandstone in Holmes County make it of little consequence as a present or future economic resource.

LOWER FREEPORT COAL

The Lower Freeport or No. 6a coal is the highest coal in Holmes County. Its horizon is confined to the highest hills in the eastern part of the county. Where seen it is everywhere thin and valueless as a source of fuel. Its position is in many places occupied by shale or by sandstone.

The Lower Freeport horizon has been eroded from all of Paint Township except for a small area at the top of the ridge on which Winesburg is located. The member is exposed 1½ miles southwest of Winesburg, along a road just south of the state road at an altitude of approximately 1,290 feet. The coal is represented by a blossom 8 inches in thickness, below which lies 5 feet of poorly exposed clay. The coal is 100 feet above the Putnam Hill limestone and 57 feet above the Middle Kittanning coal (6-205, Appendix).

A few of the higher knobs in the southeastern part of Berlin Township rise high enough above the Middle Kittanning coal to retain the horizon of the Lower Freeport coal. Coal at such a position was seen in only one exposure, along the road 1½ miles north of Clark Township, and three-fourths mile west of Walnut Creek Township, three-eighths mile north of Miller School, where the following measurements were made:

	Ft.	In.
Sandstone, shaly	11	6
Shale, sandy	22	0
Clay shale; and covered	4	6
Coal, weathered, *Lower Freeport,* altitude 1,285 feet	1	0
Clay, light, plastic	2	0

No outcrops of the Lower Freeport coal were seen in Walnut Creek Township nor are they due, except possibly at the top of one or two high knobs in the southwestern part. An indication of coal crops out obscurely along a road at an altitude of 1,260 feet at the top of the knob just west of NW¼NW¼ Sec. 23, but a satisfactory section showing its relationship to lower beds could not be secured. This coal appears to be too high for Middle Kittanning and it may be Lower Freeport.

No coal which can be identified as Lower Freeport was seen in Clark Township. It is due near the tops of the high knobs in NE Sec. 15, NW Sec. 15, and NW Sec. 14, 1¼ miles south of Charm, but massive sandstone occupies the horizon. The Lower Freeport horizon is due less than a mile south of the southeastern part of Clark Township, in SE Sec. 5, Bucks Township, Tuscarawas County, one-half mile southeast of Baltic, but its presence could not be confirmed.

None of the hills in Holmes County rises high enough above the Lower Freeport or No. 6a coal horizon to retain the horizon of the next highest coal, the Upper Freeport, or No. 7, the highest member of the Allegheny formation of rocks. There is therefore no possibility of finding in the county strata of the Conemaugh formation, which is the unit next higher in the stratigraphic column in Ohio.

PART III — GAS AND OIL

By RAYMOND E. LAMBORN

INTRODUCTION

Drilling for petroleum began in Ohio soon after the discovery of oil by the Drake well near Titusville, Pennsylvania, in 1859. About 1860 natural gas was found in the Berea sand near East Liverpool, Columbiana County, Ohio.[1] The same year marked the discovery of oil in the First Cow Run sand near Macksburg, Aurelius Township, Washington County;[2] the discovery of oil in the First Cow Run sand in Union and Homer townships, Morgan County;[3] and the beginning of oil production from the Mecca field in Mecca Township, Trumbull County.[4] The following year gas was struck in the Ohio shale at Painesville, Lake County,[5] and a little later oil was secured from the Berea sand near Belden, Lorain County.[6] Previous to the Drake discovery, the presence of oil and gas had been noted in surface seepages at some localities in eastern Ohio. These substances had also been encountered in drilling wells for salt brines, but their presence was generally considered to be more of a hazard than an economic asset.

For 25 years following the Drake discovery the producing area in Ohio was confined chiefly to the counties bordering the Ohio River in the southeast and east parts, to the northeast corner of the State, and to the counties adjoining Lake Erie as far west as Huron. A great impetus was given to the industry, however, when in 1884, large flows of natural gas were secured from wells drilled to the Trenton limestone at Findlay, and when oil was struck in the same formation at Lima the following year. During the next five years (1885-1890) one or more tests were drilled in nearly every county in the State. Production of either oil, gas, or both was secured in every county along the line of the old Trenton field in Ohio, from Mercer on the west to Ottawa on the north. New pools in the Berea sand were opened near Cadiz, Harrison County; near Barnesville, Belmont County; and near Cambridge, Guernsey County.[7]

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[1] Stout, W., and Lamborn, R. E., Geology of Columbiana County: Geol. Survey Ohio Bull. 28, p. 356, 1924.

[2] Bownocker, J. A., The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio: Geol. Survey Ohio Bull. 1, pp. 149-150, 1903.

[3] *Ibid.*, pp. 127, 140.

[4] Orton, E., Economic Geology: Geol. Survey Ohio, Vol. 6, p. 328, 1888.

[5] *Ibid.*, p. 427.

[6] *Ibid.*, p. 332.

[7] Orton, E., First Annual Report: Geol. Survey Ohio, pp. 250-257, 1890.

Stimulated by the success at Findlay a test well was started for the Trenton limestone at Lancaster, Fairfield County, in May, 1886. At a depth of 1,957 feet, a small flow of gas was secured from an horizon known as the Clinton sand.[1] Other wells followed in rapid succession, and prospecting began near neighboring towns. Thus began development of production in the Clinton sand which has proved to be the most important source of natural gas in the State. Oil was discovered in the Clinton sand in Jackson Township, Vinton County, in 1899,[2] and in Jackson Township, Knox County, 1904,[3] but no large and paying oil production was secured until 1907, when the Bremen pool was opened in eastern Fairfield County.[4] Development of oil and gas resources of the Clinton sand has gone steadily forward since 1887, until the known producing field now embraces a broad area in Ohio extending from Lawrence County on the south to Lake Erie in Lorain and Cuyahoga counties on the north.

In the search for oil and gas in the deeper strata small areas have been found where two horizons in the Big Lime series have proved productive, namely, the Oriskany and Newburg "sands." The latter was discovered at Newburg in Cleveland in October, 1911, when drilling a deep test for gas. An oil and gas well was developed in a porous limestone "sand" occurring below the salt beds in the lowest third of the Big Lime at a depth of 2,520 feet or about 500 feet above the horizon of the Clinton sand.[5] Subsequent developments have proved this horizon, the Newburg, very productive at Cleveland and vicinity and at other scattered localities in the northeast quarter of Ohio.

In 1899 two deep wells drilled at Jefferson, Jefferson Township, Ashtabula County, obtained small quantities of oil in a sandstone occurring about 300 feet below the top of the Big Lime. The following year gas was secured in this sand in a number of wells drilled northwest of Jefferson in Jefferson and Austinburg townships, and the producing horizon became known locally as the Austinburg sand (Oriskany).[6] A "stray" sand, occupying approximately the same stratigraphic horizon as the Austinburg, was encountered in drilling for the Clinton in West Park Township, Cuyahoga County, in 1913-1914 and some wells were productive of gas.[7] About 1922 a large reservoir of gas in the Oriskany sand was tapped by the drill in western Guernsey County and since that time several small pools of both oil and gas have been secured in the Oriskany sand of eastern Ohio.

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[1] Bownocker, *op. cit.*, p. 102.
[2] Bownocker, J. A., The Bremen Oil Field: Geol. Survey Ohio Bull. 12, p. 42, 1910.
[3] *Ibid.*, p. 52.
[4] *Ibid.*, p. 9.
[5] Cushing, H. P., Leverett, Frank, and Van Horn, F. R., Geology and Mineral Resources of The Cleveland District, Ohio: U. S. Geol. Survey Bull. 818, pp. 117, 119, 1931.
[6] Bownocker, *op. cit.* (Oil and Gas), p. 303, 1903.
[7] Cushing, H. P., and others, *op. cit.*, p. 118.

Since the discovery at Findlay in 1884 the search for oil and gas in Ohio has gone forward at a rate varying from a few hundred to more than 5,000 tests per year. Wells estimated at 150,000 to 175,000, in number, have been drilled to the various producing horizons in the State since 1860. Approximately 75,000 of these wells have been sunk to the Trenton limestone in northwestern Ohio. Some 608,000,000 barrels of oil and untold billions of cubic feet of natural gas have been produced since 1860. The limits of the Trenton field in northwestern Ohio, which alone has yielded approximately 376,000,000 barrels of oil since 1885, has been in general well defined. The first belt of Clinton sand production has been extended from near the Ohio River to Lake Erie and the width of the field has been increased by the discovery of many small pools east of the chief producing belt. Exploration in the Berea and shallower sands has been so extended that almost every county in the eastern third of the State has one or more oil or gas pools within its boundaries. The search continues in Ohio at an average rate of over a thousand tests a year.

In the preparation of this report much data in the form of well logs and locations of wells have been secured from the Division of Mines and from the Geology Department of the Ohio Fuel Gas Company, to whom the writer wishes to acknowledge his indebtedness and to express his appreciation.

EARLY EXPLORATIONS

The search for oil and gas began early in Holmes County, but little production was secured to reward the prospector for his trouble until about 1900. Between 1860 and 1870 a test is reported to have been drilled on the Sylvanus Purdy farm in Richland Township and is said to have produced a little gas, although the horizon reached is not known.

About 1865 a test was drilled to a depth of about 1,000 feet on the Quillen farm located 2 miles north of Killbuck, Killbuck Township, but it yielded only a show of oil and gas.[1]

Following closely the success at Findlay, a deep well was drilled at Millersburg, Hardy Township, in 1886. The drill penetrated the strata to a depth of 2,100 feet and stopped in the Ohio shale. A small show of gas was secured in the Berea sand, which was reached at a depth of 725 feet.[2] The next location was on the Netherow farm about 4 miles from Millersburg. Here a little oil and gas were secured. About 1890 a well was drilled on the Stuber property in Richland Township but it proved a failure.

From 1899 to 1901 a number of wells were drilled to the Berea sand in Richland, Washington, and Killbuck townships. Four wells were drilled near Glenmont, Richland Township, in 1899 as follows: one on the Zoller farm near Glenmont, one on the Simons property located one mile north-

[1] Bownocker, *op. cit.* (Oil and Gas), p. 287.
[2] *Ibid.*, p. 288.

east of Glenmont, and one each on the Jones and Cornell farms both situated about 2½ miles northeast of Glenmont. A show of oil and gas was secured in the Zoller well, and gas for a single residence from the well on the Jones farm was obtained. The others were failures. About the same time two wells were drilled near Nashville, but both were dry.

From 1899 to 1901 no less than 10 wells were drilled to the Berea sand in the vicinity of Killbuck. These wells were located on the Christopher and Lane farms one-half mile northeast of the village, on the Carpenter farm to the east and southeast, on the Duncan property adjoining the town, and on the Stout, Beller, and Schneeberger farms lying southwest and southeast respectively. The Berea sand was found in these wells at depths ranging from 620 to 665 feet. Shows of both oil and gas were secured in nearly every well. An initial production of five barrels was secured in the Duncan well, but the production soon dwindled. Salt water was encountered with the oil in the Christopher and Schneeberger tests.[1] For a few years following 1901, activity with the drill increased in the vicinity of Killbuck where many oil wells were secured in the Berea sand, some of which were still producing in 1939.

About 1919-1920, flows of gas were secured from wells drilled to the Berea sand in the southwest part of Sec. 16, and the north part of Sec. 25, Hardy Township. As the yield of gas was small and the market conditions poor, the wells soon fell into disuse and were abandoned.

About 1935 a small gas pool was discovered in the Berea sand, in the east central part of Mechanic Township. The producing area included parts of secs. 12, 13, and 18. Gas production has also been realized from scattered wells drilled to the Berea sand in Monroe Township and in the northwest quarter of Killbuck Township.

In the testing of the deeply buried strata in Holmes County three wells had reached the Clinton sand before 1910.[1] In 1904 a well was drilled on the Peter Schlarb farm about 3 miles west of Millersburg. The Berea sand was reached at a depth of 695 feet and is 45 feet in thickness. Sixty-seven feet of Clinton sand was penetrated at a depth of 3,188 feet but no oil or gas shows resulted. The Clinton sand was likewise reached by the drill at a depth of 3,059 feet on the Colopy farm located in the southwest part of Richland Township. Only a show of oil and gas was secured in the Clinton sand.

A third test of the Clinton sand was drilled on the Kaylor property in the west part of Sec. 15, Knox Township. The Berea sand, having a thickness of 10 feet and yielding a show of oil, was reached at a depth of 615 feet. Twenty-eight feet of Clinton sand and interstratified shale was penetrated at 2,884 feet and yielded only a show of gas.

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[1] *Ibid.*, pp. 287-288.

[2] Bownocker, *op. cit.*, (Bremen), pp. 58-59.

About 1910 a well is reported to have been drilled to a depth of about 2,800 feet on the A. J. Keim property at Charm in the northwest part of Clark Township. The well was abandoned, having yielded nothing more than a show of gas.

Between 1910 and 1920 drilling for the Clinton sand was confined chiefly to the townships lying along the west and northwest borders of the county. In 1914-1916 two dry holes are reported to have been drilled in the Clinton sand on the Priest farm in Sec. 27, Washington Township. In 1915 dry holes were drilled on the Spring farm in Sec. 5, and on the Carter farm in Sec. 31, Washington Township. The same year witnessed the drilling of a dry hole to the Clinton sand on the A. D. McQuillen farm in Sec. 13, Monroe Township. Encouragement for further exploration was secured, however, when, in 1916, oil was struck in the Clinton sand in wells drilled on the Smith and Crider farms in the southwest corner of Richland Township. A little later (about 1918) oil was likewise secured in the Clinton sand in the northeast corner of Ripley Township. Following the success in Ripley Township, activity with the drill increased in all adjacent areas in Holmes County. By 1921 oil and gas had been found in paying quantities in the Clinton sand in several wells in the west part of Prairie Township and in several wells in southern Ripley Township. The following year saw the extension of the producing areas into western Hardy Township and into eastern Monroe Township. By 1927 several small pools in the Clinton sand had been discovered in eastern Richland Township and southwestern Killbuck Township.

PRESENT DEVELOPMENT

Since drilling for oil and gas first began in Holmes County at least 1,400 wells have been sunk to either the Berea or to the Clinton sands. Of this number more than 90 percent have been drilled in the western half of the county where the oil and gas pools are greater in number and broader in extent. Commercial production of either oil or gas has been secured in every township except Salt Creek and Walnut Creek in the eastern half of the county. The Clinton sand is the chief source of oil and gas, but some production has also been secured from the Berea sand in small scattered areas throughout the county and especially in Killbuck Township.

BERLIN TOWNSHIP

Eight tests are known to have been drilled for oil and gas in Berlin Township up to 1948. Over 20 years ago a well was started on the John Boyd property in Lot 12, First Quarter. The drill penetrated to a depth of 995 feet when the tools were lost and the well was abandoned. About the same time a dry hole was drilled to the Berea sand on the Andrew C. Yoder property in Lot 25, Fourth Quarter. The sand was reached at a depth of 1,042 feet and was found to have a thickness of 15 feet. No further drilling is known to have occurred until 1917, when a Clinton test was put down on the Dan Mast property in Lot 21, Fourth Quarter. The Clinton horizon was reached at a depth of 3,775 feet. Thirty feet of sand was reported in the record but no production was secured. The next well was drilled in 1928 on the Christian Mast property, Sec. 8. The Clinton was reached at a depth of 3,851 feet but was dry. In 1934 the Clinton sand was tested on the Emanuel E. Weaver farm in Sec. 6. A show of gas was secured in the Clinton which was reached at a depth of 4,026 feet. Another test on the J. E. Beachy farm in the same section is a small gas well. A light gas producer has also been secured on the John Hushberger property located in the northwest quarter of Sec. 4. This well produces from the lower part of the Clinton sand, which lies at a depth of 4,109 feet.

CLARK TOWNSHIP

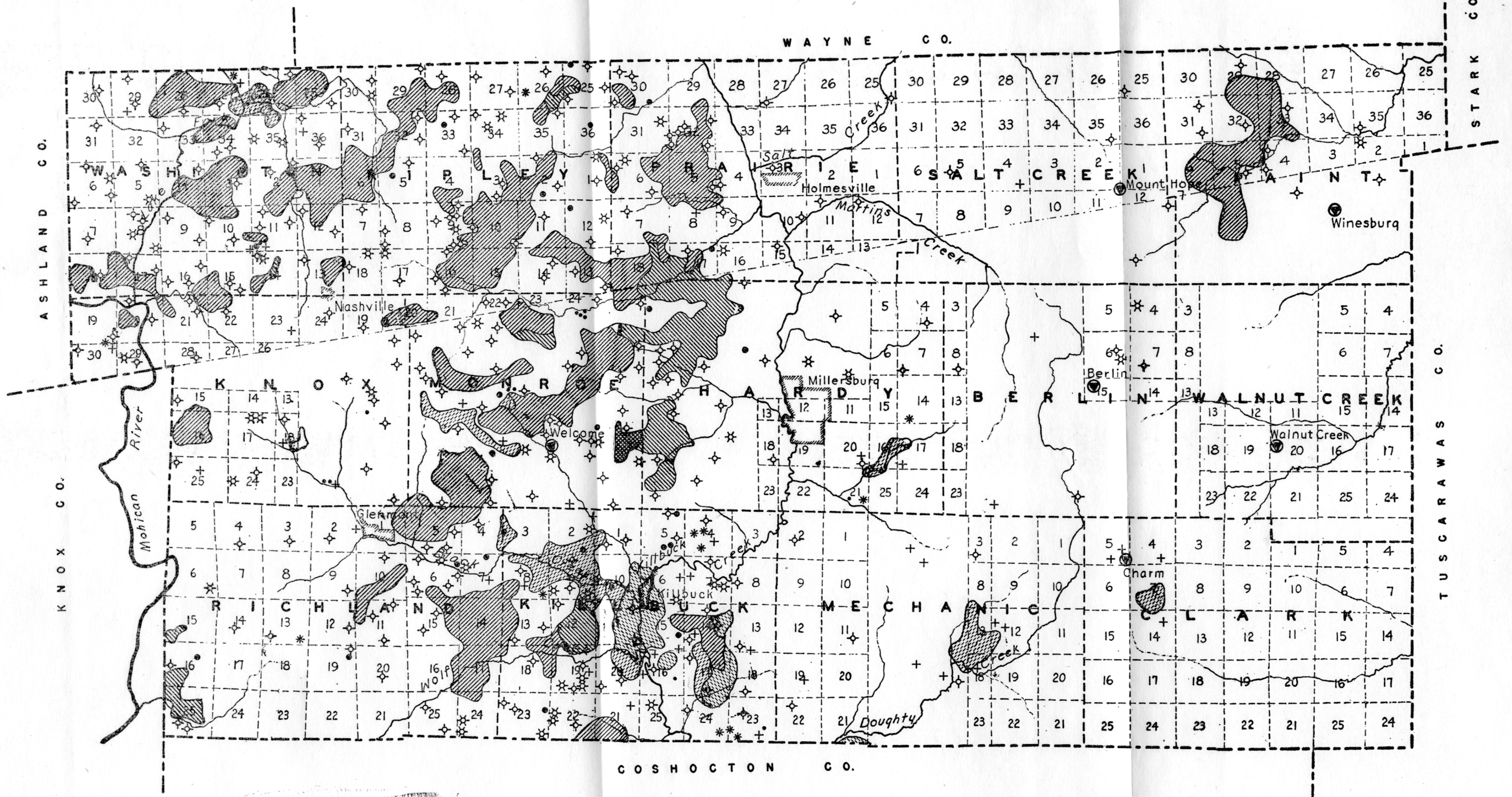
Drilling for oil and gas in Clark Township has been confined entirely to the northwest part. A well is reported to have been drilled about 1910 to a depth of 2,800 feet on the A. T. Klein property near Charm in the southwest corner of Sec. 5. A show of oil and gas is reported to have been secured, presumably from the Berea sand. About 10 years later a number of wells were drilled in Sec. 7, and although small flows of gas were secured from the Berea horizon, the production was short-lived. A list of the tests includes three small gas wells on the Morno J. Troyer farm in SW¼ Sec. 7; three small gas wells on the Noah J. Miller farm in SE¼ Sec. 7; two dry holes on the Andrew J. Troyer land in NE¼ Sec. 7; and one dry hole on the Peter C. Troyer property in SE¼ Sec. 4. The Berea sand is expected in these localities at an elevation of 50 to 100 feet above sea level.

KILLBUCK TOWNSHIP

Drilling for the Clinton sand began early in Killbuck Township. In 1911 a well was drilled on the John Arnold property in the southwest corner of Sec. 2, west, to a depth of 3,227 feet, yielding a show of oil in the Clinton sand. Another test drilled in 1919 on the McKelvey property in Sec. 23, west, proved to be a dry hole in the Clinton. In 1920 a test sunk on the Purdy property in Sec. 12 yielded both oil and gas from the Clinton sand. Other wells followed and some scattered production was secured. The areas where this sand has proved productive are confined chiefly to secs. 9, 10, 11, 12, 18, and 19 in the western half of the township. Since 1940 some gas production from the Clinton has been obtained in secs. 7, 14, and 17 in the eastern part of the township.

Drilling for oil and gas in the Berea sand near Killbuck began about 1899. Many wells have been drilled in this area since that time and both oil and gas in paying quantities have been secured. A small pool lying east of Killbuck Creek extends in a general north-south direction and embraces parts of secs. 14, 17, 18, and 24. Here the gas is confined to

MAP V



STATE OF OHIO
DEPARTMENT OF PUBLIC WORKS
GEOLOGICAL SURVEY OF OHIO
JOHN H. MELVIN, STATE GEOLOGIST
COLUMBUS
1948

HOLMES COUNTY GAS AND OIL

by R.E. LAMBORN

Miles

LEGEND

- Dry Hole, Clinton Sand
- Oil Well, Clinton Sand
- Gas Well, Clinton Sand
- Oil Field, Clinton Sand
- Gas Field, Clinton Sand
- Dry Hole, Berea Sand
- Oil Well, Berea Sand
- Gas Well, Berea Sand
- Oil Field, Berea Sand
- Gas Field, Berea Sand

the western part and is flanked by oil which is found in the eastern part of the pool.

The largest and most important productive area in the Berea sand in Killbuck Township is the Killbuck pool which lies in and around the village of Killbuck. Here the sand has yielded both oil and gas. The oil production has been secured from many wells drilled on both sides of Killbuck Creek, embracing the north part of Sec. 16, W½ secs. 6 and 15, and E½ secs. 10 and 11. Southwest and west of the oil producing belt, gas has been found in many widely scattered wells located in secs. 1, 2, 3, 8, 9, 10, 11, 12, and 20. At Killbuck the Berea sand is reached at depths of about 650. The sand has a thickness of approximately 18 feet, but is separated into two beds by a thin shale "break" which occurs near the bottom of the formation. The oil is generally found in the upper part of the sand below a thin cap rock and above the shale "break." In general the initial production of wells in this pool has been small but the wells have been long lived. An initial production of 25 bbls. after shot has been about the maximum, but one well is reported to have produced for 41 years. No strong flow of water is experienced in the Berea sand in the Killbuck pool.

KNOX TOWNSHIP

The first area drilled in Knox Township which yielded commercial production is located in the west part of Sec. 16 and the southwest part of Sec. 15. Here 10 wells have produced from the Clinton sand which occurs at depths ranging from 2,900 to 3,200 feet. Shows of oil or gas in either the Berea or Clinton sand have been reported in dry holes drilled to the Clinton horizon in secs. 18, 24, 28, Lot 2, NW¼, and lots 12 and 19, SE¼. About 1900, a light gas well was secured in the Berea sand on the Eleanor Thomas property in the southeast part of Sec. 18. A little later three other wells were drilled on the same property and the gas was utilized for light and heat in the Taylor house for nearly 40 years. Two wells drilled to the Berea sand on the Tipton property, in the southwest part of Sec. 18, are reported to have yielded good shows of oil, but the wells were never pumped. About 1916 a well was drilled to the Berea sand on the Carpenter farm in the southwest part of Sec. 13, and yielded showings of oil and gas. Showings in the Berea were likewise obtained in wells drilled in Lot 35 in the southeast quarter of the township. Here the sand is reported to occur at a depth of about 700 feet.

Since 1941 about a dozen wells have been drilled to the Clinton sand in secs. 20, 21, 22, and 29, nearly half of which have proved dry. Some small gas production has been secured, however, in the northwest part of Sec. 20, the northwest part of Sec. 21, west central part of Sec. 20, and the west central part of Sec. 29.

MECHANIC TOWNSHIP

Five wells are known to have been drilled to the Clinton sand in Mechanic Township without encouraging results. The first of these tests was sunk in 1917, on the J. G. Conrad property in SE¼ Sec. 3. A show of gas was reported in the Berea sand which was reached at a depth of 869 feet and which was reported to be 20 feet in thickness, but the Clinton sand was dry. The second test was drilled in 1927 on the John Bucklew farm in the SW¼ Sec. 2, west. Here the Clinton sand was reached at 3,319 feet and was reported to extend with only one thin shale "break" to a depth of 3,370 feet. In 1934 a third test, located on the Walter Uhl farm in Sec. 11, west, was completed without encouraging results. The fourth test drilled in 1942 on the J. E. O'Hail property in Sec. 22, west, yielded only a show of gas in the Clinton, reached at a depth of 3,590 feet. A well drilled on the Conrad property in Lot 6, south, in 1944, encountered the Clinton sand at 3,645 feet. A show of oil was reported at 3,690 feet.

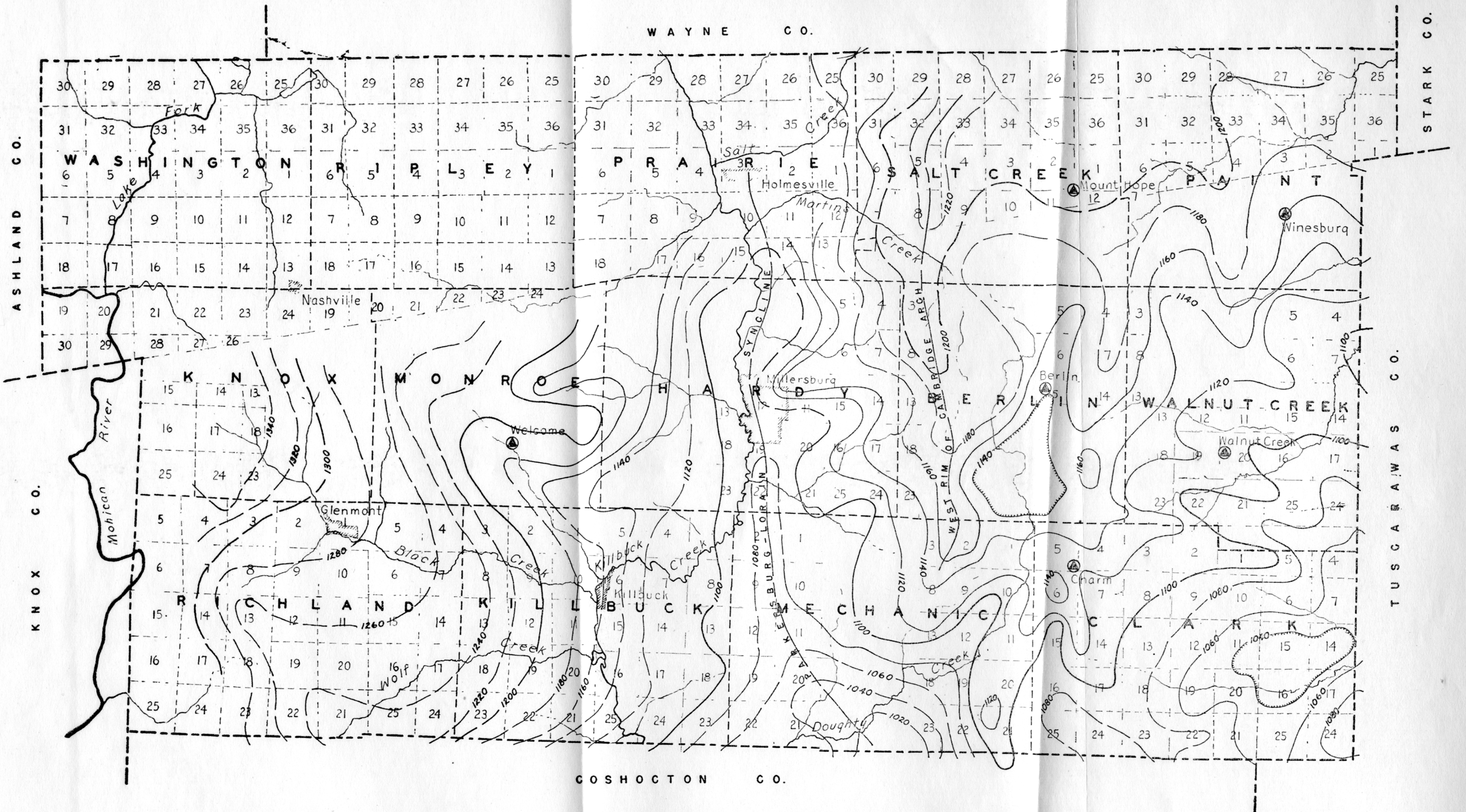
The Berea sand has yielded both oil and gas in Mechanic Township, but no large production has been obtained. A few wells drilled at Bloomfield in the southern part of Sec. 21 have produced small quantities of oil. A number of years ago a Berea well was drilled near the north edge of the C. C. Findlay property in Sec. 18, and a small flow of gas was secured which was utilized for fuel in a near-by house. In 1935 other wells were sunk on adjoining property from which small flows of gas were secured in the Berea. Additional wells have been drilled since 1935 and a small gas pool has been developed. The producing area includes NE¼ Sec. 18, E½ Sec. 13, and the eastern part of lots 7, 8, and 9, south. A number of dry holes have been drilled on the south and east sides of the producing area. In this pool the gas is secured in the upper 10 feet of the sand, which is reached at depths ranging from 775 feet to 925 feet.

In 1935 dry holes were drilled to the Berea sand on the Holly Schneeberger property in Lot 13, north, and on the Lloyd S. Finley farm in Lot 23, north. Twenty-eight feet of Berea sand was reported in each of these tests. A little later a shallow well was drilled on the Valentine Close property in Sec. 19, west, where a show of oil was secured in the Berea sand.

PAINT TOWNSHIP

Several gas wells have been secured in the Clinton sand in the west central part of Paint Township. The producing area includes parts of secs. 28, 29, 32, 33, 5, and 6, and lots 23, 24, 26, and 33, west. The Clinton sand in this field is reached at depths ranging from 4,000 to 4,050 feet. Dry holes have been drilled around the margins of the producing area in secs. 4, 5, 29, 31, 32, and 33.

In 1936 a small gas well was drilled in the Clinton sand on the Philip Miser property in the NE¼ Sec. 26, where the sand was reached at a



MAP OF
HOLMES COUNTY
SHOWING STRUCTURAL CONTOURS ON THE
PUTNAM HILL LIMESTONE

From field data by
GEORGE W. WHITE

Contour interval: 20 feet

Miles

STATE OF OHIO
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GEOLOGICAL SURVEY OF OHIO
JOHN H. MELVIN, STATE GEOLOGIST
COLUMBUS
1948

depth of 3,985 feet. Including two thin shale breaks, the Clinton sand in this well has a thickness of 80 feet, but only a thin section of it is productive.

In 1939 a small gas well was likewise secured in the Clinton sand on the Ezra Johnson farm in the NW¼ Sec. 2. A test on property adjoining on the north proved to be a dry hole in the Clinton sand. No drilling to either the Clinton or Berea sand is reported for the southeast quarter of the township.

PRAIRIE, HARDY, AND MONROE TOWNSHIPS

Shortly after 1920 natural gas was secured in wells drilled to the Clinton sand in the west central part of Prairie Township, and about the same time oil was struck in the southwest part of that township. During the years following 1920 the producing area in the Clinton has been so extended to the south and southwest that it includes much of the west half of Prairie Township, the west third of Hardy Township, and the northwest two-thirds of Monroe Township. The oil production from the Clinton is confined for the most part to southwestern Prairie and western Hardy townships. Small isolated gas pools occur in the northwest quarter of Prairie Township but the largest gas producing area extends from northeast to southwest through Monroe Township and lies in contact with the oil along the northeast margin. In all, at least 350 wells have been drilled to the Clinton sand in the producing areas in these townships. Here the sand varies in depth from 3,100 to 3,600 feet.

East of the belt of producing areas, dry holes in the Clinton sand have been drilled in secs. 3, 10, 11, 12, 15, 25, and 27, Prairie Township. In a well on the F. M. Oats property in Sec. 25, the White Clinton sand was reached at a depth of 3,445 feet, but proved dry. A show of oil and gas was reported in the Newburg, however, at a depth of 3,265 feet. In Hardy Township scattered tests have been drilled to the Clinton both east and west of Killbuck Creek east of the oil pools. Shows of gas from the Clinton horizon have been secured on the Miller property in Sec. 4 and on the Findlay and Sindlesbarger properties in lots 39 and 31, respectively, northeast quarter. Shows of gas have likewise been reported from the Clinton beds in tests drilled on the Watts and Horn properties in lots 18 and 13 respectively, southwest quarter.

In Monroe Township the Berea sand has yielded gas from many shallow wells drilled in lots 12, 22, 23, 26, 27, 39, 40, 5, and 8 in the southwest quarter and in lot 10 in the southeast quarter. Small oil wells have also been secured in the Berea sand in Lot 20 of the northeast quarter and in Lot 1 of the northwest quarter of the township. The Berea sand in these areas lies at depths ranging from 700 to 960 feet.

To the writer's knowledge the Berea sand has been productive of neither oil nor gas in Hardy Township except over one small area in secs. 16, 17, 21, and 25 in the southeast part. At least 14 wells have been drilled in this area, 10 of which have yielded small flows of gas. The first of these wells is reported to have been drilled in about 1919 and one of the early wells yielded gas for single house consumption for a period of nearly 20 years. The Berea sand, which is reached at depths ranging from 690 to 780 feet, is generally less than 10 feet in thickness.

RICHLAND TOWNSHIP

Drilling to the Clinton sand has been productive of both oil and gas in Richland Township. Production of oil from this sand has been confined for the most part to small pools in secs. 15, 16, and 25 along the west border, whereas the gas production has been secured over small disconnected areas in the east half of the township. The largest producing area in eastern Richland Township includes parts of secs. 7, 14, 15, 17, and 24 and extends into the west part of Killbuck Township. Smaller areas embrace parts of secs. 10 and 11, where six wells have yielded gas from the Clinton sand, and secs. 1, 4, and 5, where at least 14 wells have produced from the Clinton. A number of dry holes have been drilled to this sand in the northern part of secs. 6 and 7 and in the southern part of secs. 4 and 5. Dry holes have likewise been sunk to the Clinton sand between the eastern and western producing areas in this township in secs. 2, 3, 4, 7, 9, 12, 13, 14, 19, 20, and 25. Shows of gas were reported from the Clinton in tests drilled on the Reynolds and Weber properties in secs. 13 and 14 respectively.

The Berea sand is not known to have yielded commercial production in Richland Township. A few scattered wells have bottomed in this sand northeast of Glenmont and in secs. 7 and 13. In all, at least 120 wells have been drilled in Richland Township, about 70 percent of which have yielded oil or gas in commercial quantities.

RIPLEY TOWNSHIP

About 1918 the Shreve oil and gas pool of Clinton Township, Wayne County, was extended to the southwest into the northeastern part of Ripley Township. The area in Ripley Township includes parts of secs. 25, 26, and 35. Here both oil and gas have been produced from the Clinton sand at depths ranging from 3,190 to 3,240 feet. The Clinton sand has likewise yielded gas from three small pools in the central and south central parts of this township. The producing area includes part or all of secs. 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, and 16. The margins of the productive area are defined in part by dry holes drilled in secs. 1, 2, 3, 9, 11, 12, 14, and 16.

Since 1940 a small gas pool in the Clinton sand has been developed in the northwestern part of Ripley Township. The field yielding production extends southwest from Sec. 28 into eastern Washington Township and includes parts of sections 28, 29, 31, 32, 33, and 6, Ripley Township. The average depth of the sand is 3,100 feet. Dry holes drilled in secs. 17, 5, 32, 33, and 28 define the pool on the southeast and northeast sides.

The Berea sand is not known to have yielded commercial production of either oil or gas in Ripley Township.

One hundred and eighty-five wells have been drilled to the Clinton sand in Ripley Township, about 80 percent of which have yielded oil or gas.

SALT CREEK TOWNSHIP

The first well known to have been drilled in Salt Creek Township is located near the southeast corner of Section 4, on the John Schlabach property. It is reported to have been drilled between 1909 and 1914 and to have reached a depth of 2,000 feet before being abandoned. In 1928 a deep test was drilled on the Adam Karsh property in Lot 7, SE¼, but no sand was found at the Clinton horizon. A second test drilled to the Clinton the same year on the Jacob Miller farm in Sec. 35 proved to be a dry hole. A deep test, drilled in 1929 on the A. T. Kilgore land in the southwest part of Sec. 5, found the Clinton sand wanting. The Berea sand, having a thickness of 55 feet, was reached in this well at a depth of 820 feet.

Since 1940 two wells have been drilled to the Clinton horizon in the eastern part of the township, one in the southwest part of Sec. 25 and the other in Lot 14, without encouraging results.

WALNUT CREEK TOWNSHIP

No drilling is known to have occurred to either the Berea or deeper sands in Walnut Creek Township.

WASHINGTON TOWNSHIP

Drilling in search for oil and gas in Washington Township has yielded shows of gas in the Berea and many gas wells in the Clinton sand. To the end of 1947 at least 145 wells have been drilled in this township, of which 65 percent have yielded gas in sufficient quantities for commercial use. The gas occurs in a number of small scattered pools which are separated by areas where no production has been secured. Yields of gas from the Clinton sand have been obtained from wells located in every section of the township except secs. 7, 30, 31, and 32. Small production of oil has been received from a few wells in secs. 14, 11, and 3. The Clinton sand is encountered in this township at depths ranging from 2,700 to 3,100 feet.

Production from the Berea sand in Washington Township is confined chiefly to a few small scattered areas in secs. 11, 26, 27, and 35. Three wells were drilled to the Berea sand on the Huston property in SW¼ Sec. 11, two proving dry and one yielding a small flow of gas. Small flows of gas have also been secured in the Berea on the Han property in Sec. 35. Gas has been produced from a number of small wells located in the western part of Sec. 26 and the eastern part of Sec. 27. Here, according to drillers' records, the sand which is reached at depths ranging from 525 to 600 feet has a thickness ranging from 10 to nearly 100 feet.

THE SUB-SURFACE ROCKS OF HOLMES COUNTY

Information concerning the sub-surface rock series penetrated in drilling for oil and gas comes in part from drillers' descriptions and in part from the study of a few drill cuttings taken from various tests in Holmes County and from other localities in eastern Ohio. The Berea and Clinton sands are the chief producing horizons and no well in Holmes County has penetrated far below the Clinton in search for oil and gas. The discussion which follows is confined, therefore, to the Red Medina shale which immediately underlies the Clinton sand group, and to the various rock series which occur above it and below the Coal Measures. A generalized section of the rocks penetrated, with the drillers' terms, thickness in the county, and geologic correlation are given in the table on page 276.

RED MEDINA SHALE

The Red Medina shale of the driller is a persistent formation which is found at all localities in the eastern half of Ohio immediately below the horizon of the Clinton sand and associated dark shales. From its outcrop area in southwestern Ohio, where it measures from 10 to 40 feet in thickness, this formation extends under cover with increasing depth to the east and northeast. The Red Medina shale is everywhere present in the belt of Clinton sand production and it has been reached in many Clinton sand tests east of the producing fields. The maximum known thickness in Ohio occurs in northeastern Ashtabula County, where 800 feet of red rock belonging to this formation occurs below the Clinton sand group. To the writer's knowledge no test wells in Holmes County have been drilled through the Red Medina shales.

The Red Medina is composed chiefly of reddish-brown, ferruginous, calcareous, micaceous shale which is very uniform in appearance. Some greenish-gray, calcareous shale is generally present interstratified with the reddish-brown variety, especially in the lower part of the rock series, but the beds are generally thin and the total percent of the greenish type is small. Thin, sandy layers are also present interstratified with the red shale, and sandstone lenses have been reported at a few localities in Ohio. The Red Medina shale of the oil-and-gas-well driller is correlated with the Queenston shale of western New York. It is represented in part on the outcrop in southwestern Ohio by the Elkhorn shale of Upper Ordovician age.

GENERALIZED SECTION OF ROCKS PENETRATED IN WELLS

System	Formation, series, or group	Character of beds	Drillers' terms			Thickness, feet	
Mississippian	Logan	Shale and sandstone	Shale and sand			....	
	Cuyahoga	Sandstone, local	Big Injun sand			50 to 350	
		Shale, bluish gray	Shale and slate			250 to 600	
	Sunbury	Shale, brown to black	Black slate			40 to 75	
	Berea	Sandstone, gray	Sand	Berea sand		0 to 62 Average, 28	
		Shale, thin, discontinuous	Break				
		Sandstone, gray, local	Sand				
	Bedford	Shale, bluish gray, sandy and reddish brown	Shale and slate; red rock			1050 to 1850	
Devonian	Ohio	Shale, bluish gray, greenish gray, and black	Shale and slate; "Cinnamon"				
	Delaware	Limestone and dolomitic limestone, light brown and gray, with chert	Lime		Big Lime	90 to 250 Average, 183	950 to 1300
	Columbus		Lime Oriskany sand				
	Detroit River						
	Sylvania	Sandstone, calcareous, local	"First Water" horizon				
Silurian	Bass Island	Dolomite, brown	Lime			55 to 378 Average, 216	
		Dolomite, brown, impure, with some anhydrite, salt, and shale	Lime and salt beds				
	Niagara	Dolomite, white to light brown	Lime, "Second Water" at top				
	Osgood	Shale, bluish gray, dolomitic	Shale			17 to 146 Average, 78	
	Dayton	Limestone, dolomitic	Little Lime or "shell"; "Packer Shell".			18 to 71 Average, 32	
	Brassfield	Limestone, dolomitic					
		Shale with red, gray, and white sandstone bodies	Clinton sand and shale			88 to 111 Average, 96	
Ordovician	Elkhorn	Shale, reddish brown, calcareous	Red Medina			....	

CLINTON SAND

Between the Red Medina shales below and the Little Lime above there is in Holmes County a rock series, about 100 feet in thickness composed of shales and bodies of sandstone interstratified. The sandstones in this series are very productive of gas and oil at many places in a north-south belt of territory extending through east central Ohio and including portions of Holmes County. To the various sandstones of this series the driller for oil and gas has applied such terms as Clinton sand, White Clinton, Red Clinton, Clinton Stray, etc. These sandstone bodies apparently lack horizontal continuity as they cannot be correlated with certainty over any large area. Such terms, therefore, must be considered as more descriptive of the character of the sandstones of this series than as denoting definite stratigraphic horizons. Although the White Clinton is generally the most productive of oil and gas, the entire series is here considered under one heading.

The sandstones and shales of the Clinton sand series vary greatly in lithologic character and relative thickness. The shales have a dark blue, dark green, or reddish brown color and are calcareous in composition. A few fragments of dark limestone have been found in drill cuttings from these beds, indicating the presence of thin layers or nodular masses of limestone. The sandstones which are interstratified with these shales are generally fine-grained and may be reddish brown, gray, or white. The sand grains, composed in large part of quartz, are subangular in contour. Calcium carbonate in varying amounts is generally present in the rock, where it serves in part as a bond for the sand grains. Iron oxides are likewise found in the red and reddish-brown varieties. Many of the sandstones are very dense and compact and the smooth character of fracture surfaces of the rock fragments suggests the presence of secondary silica as a part of the bond holding the sand grains together. Glauconite has been observed in both the sandstones and shales of this series and in some samples it is abundant. The character of the Clinton horizon is illustrated by the following description of samples of drill cuttings from the Maude Harrold No. 1 well in Sec. 33, Paint Township. According to the driller's record the well yielded gas from the Clinton sand at depths of 4,132 to 4,170 feet. The Little Lime was passed through at 4,110 feet.

Description of samples of Clinton sand series from Maude Harrold No. 1 well, Sec. 33, Paint Township, Holmes County

	Top Ft.	Bottom Ft.
Sandstone, fine-grained; a few pieces of dark shale	4,132	4,135
Shale, dark brown to reddish brown, sandy	4,135	4,140
Sandstone, fine-grained, gray to reddish brown, calcareous; approximately 10 percent of sample is greenish-gray shale	4,140	4,145

	Top Ft.	Bottom Ft.
Same; very small amount of shale	4,145	4,148
Sandstone, grayish brown and reddish brown, fine-grained, argillaceous	4,148	4,152
Sandstone, greenish gray and brownish gray, fine-textured, argillaceous	4,152	4,156
Sandstone, grayish brown, fine-grained, with approximately 40 percent of dark greenish-gray shale	4,156	4,157
Sandstone, reddish brown, fine-grained, calcareous; a little brown gray sandstone	4,157	4,159
Sandstone as above, approximately 40 percent of sample; remainder dark bluish-gray shale rich in glauconite	4,159	4,163
Sandstone, reddish brown, fine-grained; a little reddish-brown shale	4,163	4,169
Shale, dark; with approximately 20 percent of red and gray sandstone	4,169	4,173
Shale, dark bluish	4,173	4,178
Shale, dark, with approximately 20 percent of gray, calcareous sandstone	4,178	4,183
Shale, bluish, sandy	4,183	4,188
Shale, bluish, sandy; with about 15 percent of gray, calcareous sandstone	4,188	4,192

The Clinton sand in Holmes County has been reached by the drill at depths ranging from 3,700 feet to about 4,100 feet. The difference in depth is due in part to the roughness of the topography, to the regional dip of the beds in a southeasterly direction, and to the thickening of the Big Lime and Bedford-Ohio shale series. In general the sand is shallowest in the northwest part of the county and deepest along the east margin. The Clinton sand series in Holmes County, consisting of shales and bodies of sandstone interstratified, varies in thickness according to drillers' records from 88 feet to 111 feet, with an average of about 96 feet. No directional thickening of this series as a whole has been noted in this county. The sandstone bodies begin to come into the stratigraphic section close below the Little Lime and they seem to thicken and thin irregularly, making positive correlation of layers from well to well hazardous. As the series is traced westward beyond the boundaries of Holmes County, the sandstone bodies pinch out and finally disappear from the section. The shales associated with these sandstones also pinch out before the outcrop of the horizon in southwestern Ohio is reached. The Clinton sand series is Lower Silurian in age.

LITTLE LIME

The Little Lime or Packer Shell of the driller is a comparatively thin limestone which lies immediately above the Clinton sand and shale series and which is separated from the Big Lime above by a bed of soft, calcareous shale. The Little Lime is a very persistent formation throughout the entire belt of Clinton sand production and it is widespread in distribution beyond the producing area. It varies in thickness from a few feet to as much as 75 feet. The shale which separates it from the base of the Big Lime in the first belt of Clinton sand production ranges from 75 feet in Lorain County to as much as 200 feet in Jackson County. This shale is generally calcareous, is soft and caving, and generally has a bluish-gray or greenish color. Red and pink shales are common on this horizon in southern Ohio. In Holmes County the Little Lime varies in thickness, according to drillers' records, from 18 to 71 feet, but its average thickness is about 32 feet. It is overlain by a bed of greenish gray to dark, calcareous shale which ranges from 17 to 146 feet in thickness with an average of about 78 feet. Samples of drill cuttings of the Little Lime taken from wells in Holmes County show that this formation is chiefly a crystalline, dolomitic limestone which may be bluish gray, pink, brown, greenish gray, or white in color. Pink, gray, and milky chert are generally present and in some localities are abundant. Thin shale "breaks" have been noted in the formation and glauconite is present at places in both the shale and the limestone. A description of samples of drill cuttings from the Little Lime in the T. W. Strouse No. 1 well, Lot 30, southwest quarter, Monroe Township, is given below. The base of the Big Lime was reached in this well at a depth of 3,228 feet.

Description of Samples of Little Lime from T. W. Strouse No. 1 well, Lot 30, Monroe Township, Holmes County

	Top Ft.	Bottom Ft.
Limestone, gray and pink to brownish gray, dolomitic, finely crystalline; a little milky chert; approximately 25 percent is bluish-gray, calcareous shale	3,289	3,296
Limestone, gray to pinkish gray, dolomitic; a little milky chert; a few pieces of dark green shale rich in glauconite	3,296	3,303
Limestone, gray to light brown gray, dolomitic, finely crystalline to dense chalky; a little dark shale	3,303	3,311
Same, with some glauconite	3,311	3,318
Limestone, dolomitic, and shale	3,318	3,324

The Little Lime of the driller is correlated with the Brassfield and Dayton limestone of surface outcrops in southwestern Ohio.

BIG LIME

The limestones and dolomites of the Middle and Lower Devonian and the dolomites of the Upper and Middle Silurian crop out over a large part of the western half of Ohio. This limestone and dolomite series dips to the eastward beneath younger beds, and with the addition of other strata which may not reach the outcrop, constitutes the Big Lime of the Clinton sand driller in Ohio. The thickness of this series along the outcrop ranges from about 250 feet in Scioto County to more than 900 feet in western Huron County. From the outcrop the series thickens to the northeast reaching its maximum known depth in Ohio in excess of

2,000 feet in central Columbiana County. The Big Lime is overlain by a thick series of Upper Devonian shales, and is underlain by a comparatively thin bed of shale which separates its base from the Little Lime.

In Holmes County the Big Lime has a thickness of about 950 feet in western Washington Township. This thickness increases to the east, however, for in eastern Paint Township it measures about 1,300 feet. The series consists chiefly of cherty limestones and cherty, dolomitic limestones; and dolomite with minor amounts of shale, anhydrite, salt, and sandstone. Two water horizons are generally encountered in the Big Lime of Holmes County. The First Water is found in a thin but persistent porous zone which is reached at depths ranging from 90 to 250 feet below the top of the series. This water-bearing zone is generally a porous, dolomitic limestone in Holmes County. More or less discontinuous bodies of calcareous sandstone are found on this same horizon in eastern Ohio, where it is known to the driller as the Oriskany sand. The persistence of the First Water, the occasional presence of quartz sand on this horizon, and the irregular interval to the top of the Big Lime suggest that the position of the First Water marks the disconformable surface between the Devonian and Silurian systems. The Big Lime series above the First Water is composed chiefly of cherty limestone and cherty, dolomitic limestone.

The Second Water is a strong flow of brine which is generally encountered in the lower part of the Big Lime. This brine horizon is generally present throughout the field of Clinton sand production; its position with respect to the bottom of the series, however, is subject to some variation. In Holmes County the interval from the base of the Big Lime to the Second Water horizon ranges from less than 100 feet to 380 feet but averages about 220 feet. This water is found in a porous dolomite and dolomites extend from this horizon to the base of the Big Lime. This Second Water is believed to occur at the top of the Niagara group.

That part of the Big Lime occurring between the First Water and Second Water horizons is composed chiefly of dolomites although beds of anhydrite, salt, and shale are found about the middle of the group in eastern and northeastern Ohio. This series is probably all Upper Silurian in age. It is believed to represent the thickened eastern and southeastern extension of the Bass Island formation of northwestern Ohio and the southwestern extension of the Salina formation of New York. The salt and shale beds which are widely distributed in northeastern Ohio tend to thin to the west and southwest and pinch out before the horizon comes to the surface in western Ohio. Thus, according to drillers' records, salt beds 100 feet or more in thickness are found in Paint Township in eastern Holmes County, but these beds are apparently wanting in the western part of the county where the Big Lime series is 250 feet less in thickness.

The salt beds of the Big Lime are underlain in some locations by beds of dark anhydrite-bearing, dolomitic shale and argillaceous dolomite, below which dark, crystalline dolomites extend to the horizon of the Second Water. An irregular, discontinuous, porous zone yielding oil and gas at a few places in Ohio occurs in these lower dolomites and is known to the driller as the Newburg sand. The Newburg sand may occur immediately above the Second Water of the Big Lime, but the usual position is from 10 to 40 feet or more above that horizon. The Newburg sand has yielded nothing more encouraging than shows of gas in Holmes County.

BEDFORD-OHIO SHALE SERIES

The Big Lime of the Clinton driller is everywhere overlain in the eastern half of Ohio by a thick series of shales which extend upward to the Berea sand. This shale series includes the Bedford and Ohio shale formations of surface outcrops and the so-called Olentangy shale of outcrops in central and southern Ohio. The thickness of this shale series on the outcrop ranges from about 350 feet in Adams and Pike counties to about 550 feet in southeastern Erie County. From the outcrop the series thickens under cover to the east, probably reaching its maximum depth in Ohio in eastern Belmont County and in eastern Monroe County. The greatest thickness of this series thus far penetrated in drilling in Ohio is 3,412 feet in Island Creek Township, Jefferson County, and 3,384 feet in Independence Township, Washington County. The thickening of this series along an east-west line from Pike Township, Knox County, through southern Holmes County to Perry Township, Carroll County, is about 28.8 feet per mile to the east. In Holmes County the series ranges in thickness from about 1,050 feet in the northwest corner to about 1,850 feet in the southeast corner. The Big Lime-to-Berea series is composed chiefly of bluish-gray, greenish-gray, black, brown, or reddish-brown shales. Thin sandstones or "shells" are occasionally reported by the driller as occurring in this series. One such sandstone, having a wide but irregular distribution, occurs from 15 to 75 feet below the Berea sandstone from which it is separated at many localities by reddish-brown and bluish-gray shales. This sandstone, known as the Second Berea and correlated with the Euclid sandstone of the Bedford formation, has not been recognized in Holmes County, although red shales are occasionally reported in drillers' records as occurring close below the Berea sand.

One or more well-defined beds of chocolate brown to brownish black, soft shale are generally encountered in the lower half of the Bedford-Ohio shale series. These dark shales are generally designated in drillers' records as "cinnamon" shale. Where two well-defined beds of brown shale occur separated by gray shale they are generally known as the Little

Cinnamon, above and Big Cinnamon, below. Showings of gas are of widespread occurrence in the Cinnamon and small production has been secured from these shales at widely scattered places in the eastern half of the State. The Cinnamon shales are generally present in Holmes County, but individual beds of this shale seem variable in thickness and seem to lack horizontal continuity. Production of gas has been secured from these shales in a few wells in the western half of Holmes County.

BEREA SANDSTONE

The Berea sandstone, so called because of its occurrence near Berea, Cuyahoga County, is widely distributed under cover in the eastern half of Ohio. Here, where it is known to the driller as the Berea sand, it is widely sought as a source for oil and gas. The outcrop of the Berea sand extends as a narrow belt from southern Ashtabula County west to southeastern Erie County and thence south through eastern Franklin, eastern Ross, and eastern Adams counties. The thickness on the outcrop ranges from a few feet to 200 feet but probably averages around 35 to 40 feet. From its outcrop the sandstone extends as a sheet deposit beneath younger beds to the east and southeast, reaching a maximum depth from the surface of about 2,000 feet in eastern Monroe and Washington counties and in eastern Meigs County. The Berea sand is the source rock of many oil and gas pools in the eastern half of Ohio.

The Berea sandstone is nearly everywhere present in Holmes County where it is encountered in wells at depths ranging from about 500 to 1,200 feet. The thickness of the sand according to drill records ranges from a few feet to 100 feet with an average of about 28 feet.[1] The sand is generally gray to bluish gray in color and is fine to medium-fine-grained in texture. The grains are mostly subangular in contour and are generally composed of quartz. Fragments of pyrite, mica, and some dark minerals have also been observed. Most Berea sandstone is not so firmly bonded as the Clinton because fracture planes of the Berea rock fragments are generally rough and granular. Calcium carbonate serves in part as the cementing substance as indicated by limited effervescence on application of dilute hydrochloric acid to samples. The pay sand is generally less firmly bonded and more porous than the unproductive portions of the formation. The following is a description of samples of Berea sand from the Maude Harrold No. 1 well in Paint Township, Holmes County:

Description of samples of Berea sandstone from Maude Harrold No. 1 well, Sec. 33, Paint Township

	Top Ft.	Bottom Ft.
Sandstone, gray, fine-grained, calcareous; a little black-shale caving	1,022	1,026
Same, a little coarser-grained; some dark minerals present	1,026	1,028

[1] See Map of Berea Sand of Northern Ohio, U. S. Geol. Survey, Preliminary Map 39, Oil and Gas Investigations, by J. F. Pepper, and others, 1945.

	Top Ft.	Bottom Ft.
Sandstone, light gray to white in color	1,028	1,030
Sandstone, gray, fine-grained, micaceous, calcareous	1,030	1,043
Sandstone, bluish gray, fine-grained, argillaceous	1,043	1,050
Sandstone, dark bluish gray, fine-grained, argillaceous, micaceous	1,050	1,055

Neither oil, gas, nor water was secured from the Berea sand in this well.

In some localities in Holmes County the Berea is divided into two parts by a shale "break" a few feet in thickness. In Mechanic and Killbuck townships, where production has been obtained in the Berea, the pay is generally found in that part of the sand which occurs above the shale "break." The following record illustrates the two-fold character of the Berea sand.

Record of the Zella Logsdon No. 1 well drilled by Bell Brothers, Sec. 13, Mechanic Township

		Top Ft.	Bottom Ft.
Soil and clay		0	40
Shale		40	80
Sand		80	110
Shale, dark		110	150
Shale, light		150	240
Sand		240	280
Shale		280	300
Sand		300	340
Shale, light and dark		340	380
Sand		380	410
Shale, dark		410	429
Shale, light and dark		429	848
Shale, brown		848	908
Sand	*Berea*	908	913
Slate, dark	*Berea*	913	928
Sand	*Berea*	928	933
Slate, bluish		933	946
Total depth			946

In this test the Berea sand yielded a show of gas at 928 to 933 feet.

BEDS OF MISSISSIPPIAN AGE ABOVE THE BEREA SANDSTONE

The rock series of Mississippian age above the Berea sandstone in Holmes County consists of shales, thin sandstones, and shales interstratified, and in parts of the county, one or more beds of massive sandstone. The thickness of this sandstone and shale series varies from about 600 feet to 840 feet. These variations in thickness are due in part to pre-Pennsylvanian erosion which removed the Maxville limestone, the highest Mississippian formation in Ohio, and cut to varying depths in the underlying sandstones and shales. The sandstones and shales of Mississippian age above the Berea are productive of neither oil nor gas in commercial quantities in Holmes County. The Berea sandstone is generally overlain in this area by a bed of black to brownish-black, carbonaceous shale frequently called "coffee" shale by the driller. According to drillers' records this shale is very persistent. It is reported in many records in Holmes County, where it has a thickness ranging from 40 to 75 feet; it is widely recognized to the south and southeast of this area. These black shales immediately overlying the Berea sandstone represent the continuation under cover of the Sunbury shale of surface outcrops. From the top of the Sunbury, bluish-gray shale and bluish-gray shale with thin sandstone interstratified extend upward for a distance varying, according to drillers records, from 250 feet to about 600 feet. These bluish shales and their interbedded sandstones occupy the stratigraphic position of the Cuyahoga shales on surface outcrops. The Hamden, Welch Stray, or Weir sand, which occurs in some localities in southern and southeastern Ohio within 100 feet of the top of the Berea, and which may be correlative with the Buena Vista sandstone member of the lower part of the Cuyahoga formation, is not recognized in Holmes County.

The Big Injun sand which produces oil and gas in Monroe, Noble, and Washington counties, and which is correlated with the Black Hand sandstone, the top member of the Cuyahoga formation, is not strongly developed in Holmes County. Irregular bodies of sandstone on this horizon of apparently local development have been penetrated at widely scattered localities. These bodies of sandstone range from 50 to 350 feet or more in thickness, and in places are separated into two or more beds by shale partings. The increased thickness of sandstone is generally accompanied by a corresponding decrease in the thickness of the underlying shales. In general the Big Injun sand is more massive in the east part of the county. No commercial production of oil or gas has been secured from the Big Injun sand in this area. The Squaw sand, which lies close below the Big Injun, and the Keener sand, occurring above and near the top of the Mississippian series, have not been recognized in Holmes County by the driller.

Description of Samples of Drill Cuttings from The Ohio Oil Company No. 1 Well Drilled on F. H. Oats Property, Sec. 25, Prairie Township, Holmes County.[1]

Completed October 23, 1941.

Samples from The Ohio Oil Company, Findlay, Ohio.

Mississippian System	Top Ft.	Bottom Ft.
Waverly group		
Siltstone, gray to bluish gray; with a small amount of dark shale	60	130
Shale, gray to gray black, somewhat sandy	130	170

[1] See also West Virginia Geological Survey Vol. VVII pp. 792-795, 1945, for a record of this well.

	Top Ft.	Bottom Ft.
Sandstone, drab, fine-grained, micaceous, grain free; with a small amount of dark shale	170	220
Shale, dark gray, micaceous	220	260
Shale, dark gray and yellowish brown, sandy	260	270
Same; 10% gray, fine-grained sandstone	270	280
Sandstone, gray, fine-grained; 10% dark gray shale	280	290
Shale, gray to gray black	290	380
Shale, gray to gray black; 50-75% gray siltstone	380	420
Shale, dark gray; a few fragments of siltstone	420	480
Shale, gray black; 50% gray siltstone	480	500
Shale, gray black, micaceous, some gray siltstone	500	655
Shale, black, carbonaceous	655	680
Same; a few pieces of gray siltstone	680	690
Berea formation		
Siltstone, gray, calcareous; traces of pyrite	690	715
Shale, dark; 25% gray siltstone	715	757
Shale, dark; trace of siltstone	757	764
Bedford formation		
Shale, dark gray to bluish gray; pyrite	764	770
Shale, dark gray, bluish gray, gray black	770	880
Devonian System		
Ohio shale		
Shale, gray to gray black, micaceous; traces of brown black shale	880	890
Shale, gray to gray black	890	930
Same, traces of brown black shale	930	940
Shale, gray to gray black, generally micaceous	940	1236
Shale, chiefly gray to gray black	1236	1355
Shale, brown black, carbonaceous	1355	1440
Shale, gray black and brown black interstratified	1440	1641
Shale, brown black, highly carbonaceous	1641	1689
Shale, gray black and brown black interstratified	1689	1770
Shale, brown black, highly carbonaceous	1770	1818
Shale, gray black and brown black, interstratified	1818	2062
Shale, brown black, highly carbonaceous	2062	2127
Devonian limestone		
Limestone, gray, dense to crystalline; 50% dark shale	2127	2135
Limestone, gray, crystalline, 10% dark shale	2135	2141
Limestone, gray to brown, dense, flaky; some pyrite; trace of dark shale	2141	2160
Limestone, brown to gray, dense; 5% dark shale	2160	2172
Limestone, gray to light brown, dense, somewhat flaky; white, gray, and brown chert increasing downward to 15%	2172	2203
Limestone, gray to light brown, dense, cherty; 2% dark shale	2203	2252
Limestone, gray to light brown, dense to crystalline; some white chert	2252	2268
Limestone, gray to light brown, generally dense, cherty; trace of shale	2268	2304
Limestone, gray, cherty; 40% gray black shale	2304	2312

	Top Ft.	Bottom Ft.
Limestone, gray, dense, cherty; 20% dark gray to gray black shale; trace of glauconite	2312	2332
Oriskany horizon		
Limestone, gray, dense to finely crystalline; fragments of chert in aggregates; a few sand grains; traces of pyrite and glauconite	2332	2338
Helderberg (?) group		
Limestone, dolomitic, gray to brownish gray, dense to finely crystalline; traces of dark gray to gray black shale	2338	2360
Silurian System		
Monroe-Salina group		
Dolomite, brown, dense to finely crystalline, slightly argillaceous	2360	2390
Same; with 5% to 15% dark gray to slate-colored shale	2390	2406
Dolomite, brown, dense to finely crystalline; small brown and gray chert; trace of white anhydrite	2406	2442
Dolomite, brown; 25 to 50% white anhydrite	2442	2464
Dolomite, dull brown, dense, impure; some white anhydrite	2464	2500
Dolomite, brown to grayish black, dense, argillaceous; small amount of white anhydrite	2500	2521
Dolomite, dark brown, dense, impure dolomite, small amount of white anhydrite	2521	2669
Dolomite, dark brown, dense to finely crystalline; a little anhydrite	2669	2702
Dolomite, brown, gray black, somewhat argillaceous and impure, parts shaly; a little anhydrite	2702	2872
Dolomite, dark brown, dense at top but becoming finely crystalline downward; trace of anhydrite	2872	2952
Dolomite, dark buff to brown, very fine cuttings	2952	2960
Niagara group		
Dolomite, white, gray to light buff; crystalline; fine cuttings	2960	3196
Dolomite, brown, finely crystalline	3196	3210
Dolomite, dark gray; 50% dolomitic shale; some pyrite	3210	3220
Dolomite, gray, dense to finely crystalline, impure	3220	3240
Dolomite, white, gray, bluish gray, crystalline	3240	3298
Dolomite, grayish brown, crystalline	3298	3304
Dolomite, dark gray, siliceous, impure	3304	3312
Osgood shale		
Shale, gray to gray black, dolomitic; 25% dark, highly siliceous dolomite	3312	3320
Shale, gray black, somewhat dolomitic	3320	3388
Dayton-Brassfield limestone		
Limestone, brown, crystalline, dolomitic, with chert; traces of glauconite, a few fragments of dark shale	3388	3392
Limestone, gray to brown, crystalline, dolomitic; white and brown chert present; traces of glauconite	3392	3414

Clinton sand group		
Shale, greenish, with pyrite	3414	3417
Shale, greenish; 50% gray, fine-grained sandstone	3417	3423
Sandstone, gray, fine-grained; 10% gray to gray black shale, traces of glauconite	3423	3431
Shale, reddish brown; a few percent of greenish black shale..	3431	3439
Shale, greenish black to gray black	3432	3459
Shale, gray black; 50% dark gray sandstone chips; traces of reddish-brown shale and hematite ore	3459	3467
Sandstone, gray, fine-grained; 30% gray black shale	3467	3473
Shale, gray black; 15% gray, fine-grained sandstone	3473	3487
Shale, gray black; 20% to 50% gray, fine-grained sandstone	3487	3514
Shale, gray to gray black	3514	3542
Same; a few fragments of dark sandstone and of pink limestone	3542	3574
Shale, gray black; many fragments of dark gray limestone ..	3574	3587
Ordovician System		
Queenston shale		
Shale, reddish brown, generally calcareous	3587	3689
TOTAL DEPTH		3689

SUMMARIES OF REPRESENTATIVE DEEP WELL LOGS

Township	Section or lot	Property owner	No. of well	Well head elevation	Berea		Big Lime		Oriskany Sand		Newburg		Second water		Little Lime		Clinton Sand		Total depth	Remarks
					Top	Btm.	Top	Btm.	Top	Btm.	Top	Btm.	Top	Btm.	Top	Btm.	Top	Btm.		
Berlin	Lot 4	John Hershberger	1		1,036	1,078	2,710	3,907			3,660	3,665			3,981	4,021	4,044 4,109	4,047 4,127	4,182	Show of oil in Newburg Gas well in Clinton
Berlin	Lot 6	E. E. Weaver	1	1,175.8	990	1,015	2,640	3,820			3,600	3,620			3,936	3,956	4,026	4,066	4,123	Show of oil in Newburg Show of gas in Clinton
Berlin	Lot 8	Christian Mast	1		990	1,045	2,530	3,703									3,851	3,891	3,987	Dry in Clinton
Berlin	Lot 21, S.W. Qr.	Dan Mast	1		845	870	2,450	3,635									3,775	3,805		Dry in Clinton
Hardy	Lot 32, N.W. Qr.	S. S. Troyer	3		915	930	2,260	3,351	2,500				3,020		3,444	3,469	3,527	3,571	3,603	Dry in Clinton
Hardy	Lot 25, S.W. Qr.	H. H. Netherow	1		893	903	2,220	3,306									3,453	3,483	3,517	Dry in Clinton
Hardy	Lot 18, N.E. Qr.	J. W. Eis	1	896	668	693	2,055	3,185							3,248	3,278	3,316	3,324	3,470	Dry in Clinton
Hardy	Lot 31	James Gundelsberger	1	1,118	900	905	2,300	3,470	2,570				3,130		3,513	3,543	3,601	3,619	3,630	Gas in Clinton
Hardy	Lot 7	R. J. Findlay	1		940	1,015	2,437	3,590							3,658	3,688	3,747	3,756	3,870	Dry in Clinton
Hardy	Lot 20	John D. Maxwell	1		720	745	2,180	3,310		2,430					3,380	3,410	3,435	3,465	3,725	Dry in Clinton
Killbuck	Lot 2	C. M. Hoopes	1		640	652	1,930	3,020		2,145				2,680	3,097	3,139	3,165	3,199	3,247	
Killbuck	Lot 5	Stephen Corns	1		870	880	2,210	3,300		2,450				2,998	3,362	3,387	3,451	3,489	3,494	Oil and gas show in Clinton
Killbuck	Lot 13	A. C. Fites	2		745	805	2,032	3,081	2,212				2,730		3,154	3,190	3,212	3,244	3,246	Gas in Clinton
Killbuck	Lot 11	E. Carpenter	1		621	624	1,945	2,910		2,165				2,690	3,115	3,139	3,174	3,221	3,234	Dry in Clinton
Killbuck	Lot 14	Frank Carpenter	1		910	960	2,275	3,360		2,515				3,070	3,428	3,467	3,504	3,554	3,610	Dry in Clinton
Killbuck	Lot 23	McKelvey	1		795	810	2,060	3,130		2,210					3,205	3,240	3,295	3,324	3,431	Dry in Clinton
Killbuck	Lot 25	W. D. Gray	1		635	655	1,965	3,030	2,130				2,700		3,086	3,116	3,143	3,198	3,218	Gas in Clinton
Knox	Lot 30	L. S. Sidle	2		752	825	1,835	2,762									2,925	2,955 2,925	3,002 2,955	Dry in Clinton
Knox	Lot 28	N. R. and Mary Beans	1		745	760	1,853	2,835		2,039				2,566	2,930	2,955	3,010	3,020	3,051 3,044	Dry in Clinton
Knox	Lot 24	C. P. Gallwitz	1	1,032.5	684	726	1,835	3,891	2,000				2,500		2,946	2,981	3,003	3,048	3,163	Dry in Clinton
Knox	Lot 16	W. W. Scott	1		936	986	2,078	3,046		2,234				2,731	3,135	3,170	3,197	3,224	3,224	Gas in Clinton
Knox	Lot 18	W. and W. H. Gray	1	1,024	678	775	1,810	2,839	2,025				2,465				3,021	3,031	3,067	Shows of gas in Berea and Clinton
Knox	Lot 12, S.E. Qr.	Wallace and Helen Bell			978	993	2,195	3,240	2,375	2,390			2,960	2,975	3,310	3,335	3,398	3,413	3,430	Shows of gas in Berea and Clinton
Mechanic	Lot 3	J. G. Conrad	1	1,037.4	869	889	2,414	3,579							3,664	3,686	3,723	3,764	3,865	Dry in Clinton
Mechanic	Lot 2	John Bucklew	1		685	715	2,085	3,185									3,319	3,370	3,457	Dry in Clinton
Mechanic	Lot 11	Walter C. Uhl	1	1,011	913	943	2,350	3,446					3,340		3,546	3,576	3,636	3,650	3,797	Dry in Clinton
Mechanic	Lot 13, N. half	Holly Schneeberger	1		1,010	1,038													1,060	Dry in Berea
Mechanic	Lot 18	Cliff Craig	1		818														824	Gas in Berea
Mechanic	Lot 13	G. C. Findlay	3		870	913													915	Gas in Berea
Mechanic	Lot 12	H. C. Logsdon	2		913	944													963	Dry in Berea
Mechanic	Lot 13, S. half	O. E. Boyd	1		896	903													948	Show of oil in Berea
Monroe	Lot 23	Alice E. Hart	1	1,022.3	735	750	2,026	3,085	2,195	2,257			2,885		3,160	3,188	3,215	3,270	3,289	Gas in Clinton
Monroe	Lot 5, N.W. Qr.	J. B. Finney	2	1,118.8	840	860	2,128	3,195					3,024		3,248	3,276	3,340	3,351	3,398	Gas in Clinton
Monroe	Lot 31, N.E. Qr.	Jesse Powers		1,059	800	825	2,080	3,168	2,300				2,895		3,215	3,255	3,279	3,301	3,334	Oil in Clinton
Monroe	Lot 11, S.W. Qr.	William E. Powers	1	1,219.6	905	925	2,175	3,240	2,365						3,300	3,337	3,360	3,404	3,442	Gas in Clinton
Monroe	Lot 19, S.W. Qr.	Hanna M. Tidball	1	1,109.6	780	785	2,034	3,114	2,227	2,250				3,114	3,169	3,196	3,224	3,274	3,296	Gas in Clinton
Paint	Lot 26	Philip Mizer	1	1,040.7	760	794	2,725	3,829			3,577	3,590			3,944	3,966	3,985	4,065	4,130	Gas in Clinton
Paint	Lot 4	A. E. Weaver	1		910	950	2,615	3,905							3,968	3,991	4,066	4,155	4,155	
Paint	Lot 5	A. M. Miller	1		842	890	2,548	3,821									3,992	4,014	4,073	Dry in Clinton
Paint	Lot 33, S.W. Qr.	S. S. Miller	1		985	1,035	2,695	3,905	2,860	2,880			3,850	3,860	4,024	4,053	4,068	4,120	4,170	Gas in Clinton
Paint	Lot 33	Maude Harrold	1	1,253.2	1,022	1,062	2,750	3,985	2,940		3,755	3,765			4,082	4,110	4,132	4,170	4,264	Gas in Clinton
Paint	Lot 29	Moses S. Miller	1	1,147.4	930	970	2,630	3,813	2,795	2,825			3,740		3,959	3,995	4,010	4,089	4,176	Dry in Clinton
Paint	Lot 29	Levi I. Yoder	1	1,172.1	965	1,010	2,655	3,912					3,475		3,996	4,022	4,047	4,119	4,314	Gas in Clinton
Prairie	Lot 30	Carnelia Lacky	2	1,044	725	755	2,045	3,149							3,199	3,235	3,280	3,297	3,298	Dry in Clinton
Prairie	Lot 32	John Haas	2	996	700	720	2,058	3,238	2,239				3,039		3,217	3,255	3,295	3,333	3,337	Gas in Clinton
Prairie	Lot 7	Amos H. Graven	1		870	925	2,205	3,271	2,410				3,015		3,392	3,420	3,454	3,506	3,520	Oil in Clinton
Prairie	Lot 25	F. H. Oats	1		690	710	2,135	3,311	2,406				2,982		3,384	3,414	3,431	3,520	3,689	Dry in Clinton
Prairie	Lot 12	F. W. Mast	1	1,079	950	960	2,340	3,510	2,590				3,230		3,565	3,612	3,637	3,650	3,735	Dry in Clinton
Richland	Lot 4	Bertha E. Johnson	1		955	965	2,100	3,060	2,238	2,275			2,900		3,197	3,229	3,282	3,297	3,316	Dry in Clinton
Richland	Lot 25	R. Grider	4		701	780	1,863	2,825							2,899	2,918	2,988	2,993	3,003	Oil in Clinton
Richland	Lot 13	W. R. Reynolds	1		875	895	2,050	3,070			2,830	2,840			3,145	3,175	3,187	3,224	3,377	Gas in Clinton
Richland	Lot 11	Charles McFarland	1	1,204.6	968	982	2,212	3,269	2,352	2,508					3,334	3,358	3,382	3,425	3,524	Dry in Clinton
Richland	Lot 25	Louis P. Vernon	1	1,072.4	900	910	2,120	3,171	2,270	2,290	2,780	2,800			3,249	3,269	3,292	3,353	3,396	Dry in Clinton
Ripley	Lot 33	Julius E. Gashe	1	1,223.3	900	915	2,145	3,296	2,307	2,345	2,975	2,984	2,984	3,000	3,277	3,296	3,332	3,380	3,407	Dry in Clinton
Ripley	Lot 34	Thomas L. Hughes	1	1,210.2	900	906	2,145	3,195	2,300	2,315			2,934	2,985	3,260	3,286	3,356	3,373	3,375	Gas in Clinton
Ripley	Lot 13	J. E. Tschantz	1	1,040	758	788	2,077	3,200	2,310				2,880		3,241	3,294	3,295	3,350	3,358	Gas in Clinton
Ripley	Lot 8	Desbro Campbell	1		917	920	2,105	3,175	2,335						3,230	3,265			3,432	Dry in Clinton
Salt Creek	Lot 5	A. T. Kilgore	1	1,047.6	820	875	2,377	3,541			3,220	3,226	3,335		3,625	3,696			3,848	No Clinton Sand
Salt Creek	Lot 7, S.E. Qr.	Adam Karch	1		906	936	2,575	3,790									3,937	3,973	4,117	Dry in Clinton
Washington	Lot 28	W. H. Fulmer	1	927.7	550	562	1,635	2,622	1,825	1,843	2,385	2,395	2,445	2,460	2,683	2,708	2,729	2,810	2,847	Dry in Clinton
Washington	Lot 33	Amos Lifer	1		560	570	1,680	2,679	1,890				2,510		2,719	2,754	2,825	2,833	2,854	Gas in Clinton
Washington	Lot 5	Harvey M. Berry	1	935.6	544	556	1,635	2,626	1,830	1,843			2,440	2,450	2,689	2,719	2,785	2,795	2,826	Gas in Clinton
Washington	Lot 18	J. M. Wiseman	1	1,128.6	790	800	1,828	2,777	2,008	2,017			2,605	2,612	2,860	2,887	2,922	2,959	2,964	Gas in Clinton
Washington	Lot 11	George Huston	1		825	870	1,960	2,970	2,183				2,930		3,041	3,083	3,152	3,164	3,189	Oil and gas in Clinton

APPENDIX

AVERAGE INTERVALS[1] IN HOLMES COUNTY

BETWEEN ADJACENT MEMBERS

	Number of measurements on which based	Ft.	In.
Lower Freeport coal to *Middle Kittanning* coal	(1)	57	4
Middle Kittanning coal to *Lower Kittanning* coal	(33)	43	5
Lower Kittanning coal to *Putnam Hill* limestone	(69)	39	8
Putnam Hill limestone to *Tionesta* coal	(31)	27	2
Tionesta coal to *Bedford* coal	(25)	28	9
Bedford coal to *Upper Mercer* coal	(13)	10	2
Upper Mercer coal to *Lower Mercer* limestone	(8)	16	11
Lower Mercer limestone to *Flint Ridge* coal	(11)	8	7½
Flint Ridge coal to *Lower Mercer* coal	(11)	14	11
Lower Mercer coal to *Vandusen* coal	(5)	11	1
Vandusen coal to *Bear Run* coal	(3)	24	3

BETWEEN CERTAIN NON-ADJACENT MEMBERS

	Number of measurements on which based	Ft.	In.
Putnam Hill limestone to *Bedford* coal	(34)	50	1
Bedford coal to *Lower Mercer* limestone	(39)	24	1
Bedford coal to *Harrison* ore	(8)	117	0
Bedford coal to *Quakertown* coal	(5)	109	11
Lower Mercer limestone to *Quakertown* coal	(4)	84	5
Lower Mercer limestone to *Harrison* ore	(10)	97	4
Lower Mercer limestone to *Lower Mercer* coal	(11)	23	7

AVERAGE THICKNESS OF MEMBERS IN HOLMES COUNTY

	Number of measurements on which based	Ft.	In.
Lower Freeport (No. 6a) coal	(3)	1	1
Lower Freeport clay	(2)	4	0
Washingtonville shale	(7)	1	8
Middle Kittanning (No. 6) coal	(53)	2	0
Middle Kittanning clay	(22)	3	10
Hamden carbonaceous and calcareous shale	(5)	1	1
Lower Kittanning (No. 5) coal	(79)	2	0½
Lower Kittanning clay	(19)	5	4
Putnam Hill limestone	(93)	3	4½
Clay shale	(44)	0	2½

[1] Intervals are from base of lower member named to base of higher member.

	Number of measurements on which based	Ft.	In.
Brookville (No. 4) coal — coal		0	6
Brookville (No. 4) coal — clay	(34)	0	2
Brookville (No. 4) coal — coal		0	9
Brookville coal, no detail	(77)	1	1
Brookville (No. 4) clay	(45)	6	5
Tionesta (No. 3b) coal	(27)	0	4½
Tionesta clay	(8)	4	1
Upper Mercer limestone	(25)	1	11¼
Bedford coal — coal		1	0
Bedford coal — clay shale	(17)	0	9
Bedford coal — coal		1	4½
Bedford coal, no detail	(81)	1	8
Bedford clay	(21)	3	0
Upper Mercer (No. 3a) coal	(13)	1	3
Upper Mercer clay	(3)	1	6
Lower Mercer ore	(10)	0	4
Lower Mercer limestone	(61)	2	10½
Middle Mercer coal	(37)	0	9
Middle Mercer clay	(13)	4	3
Flint Ridge coal	(10)	0	7
Flint Ridge clay	(4)	2	11
Boggs ore	(2)	0	6
Lower Mercer (No. 3) coal	(16)	1	5
Lower Mercer clay	(4)	1	7
Poverty Run calcareous ore	(2)	2	1
Vandusen coal	(5)	0	8
Vandusen clay	(3)	3	5
Bear Run coal	(4)	0	7
Bear Run clay	(2)	5	0
Massillon sandstone, generally replaces all members from *Flint Ridge* to *Bear Run* coal	(20)	47	7
Quakertown (No. 2) coal	(24)	1	7½
Quakertown clay	(6)	1	9
Harrison ore (including conglomerate)	(14)	1	1

STRATIGRAPHIC SECTIONS FROM HOLMES COUNTY

The stratigraphic sections are arranged from Paint Township, in the northeastern corner of the county, westward across Salt Creek, Prairie, and Ripley townships; thence southward to Knox Township and east across Monroe, Hardy, Berlin, and Walnut Creek townships; thence south to Clark Township (German on older maps) and west across Mechanic, Killbuck, and Richland townships. Within each township the sections are arranged from the northeast part westward to the northwest part, thence south and east to the southeast part.[1]

The number of each section is in two parts separated by a dash, for example 32-318. The first part of the number (32-, left of the dash) is the "consecutive number" by which the section is placed in its position in the county, and indicates the order given in this Appendix, from 1- to 169-. The second part of the number can be disregarded by the usual reader. It is the "field number" of field notes and maps and is preserved for certain office uses.

The location within the townships is given by land survey section and by quarter (in some cases quarter of a quarter) of a section. Thus: SE¼NW¼ Sec. 3 should be read "the southeast quarter of the northwest quarter of Section 3. The civil townships of Holmes County do not coincide with land survey townships. Consequently certain townships have two sections with the same number. For this reason the part of a township is often specified as well as the section number. Parts of certain townships are not divided into sections. In these areas locations are given by distance and directions from some prominent feature and often by reference to township lines.

STRATIGRAPHIC SECTIONS FROM PAINT TOWNSHIP

1-228. In ravine in field NW¼NE¼ Sec. 36, NE Paint Twp.

	Ft.	In.
Clay shale	10	0
Old mine opening, *Lower Kittanning*	4	0
Covered and shale, ferruginous	20	0
Limestone, loose blocks, *Putnam Hill,* altitude 1,110 feet	3	0
Covered	30	0
Old mine opening, evidently not carried far, *Bedford*	4	0

2-229. In small quarry on farm of A. T. Weaver and W to hilltop, SW¼SW¼ Sec. 26, N Paint Twp.

	Ft.	In.
Covered	2	0
Coal, blossom, *Lower Kittanning*	0	6
Clay, light, plastic	5	0
Clay shale, ferruginous	38	8
Limestone, blue gray, hard, dense, platy, fossiliferous, *Putnam Hill,* altitude 1,200 feet	3	11
Clay shale	0	2
Coal, shaly (*Brookville*)	0	1½
Clay shale, gray, dark (*Brookville*)	0	2
Coal, good (*Brookville*)	1	2
Clay, carbonaceous, dark, impure	0	6
Clay, light, plastic, siliceous, and covered	7	0
Shale, sandy; and covered	25	0

[1] A few sections are given from adjacent counties. These are listed with the nearest township in Holmes County.

3-232. In bank of Mt. Eaton-Winesburg road ⅛ mile S of Wayne-Holmes county line, NW¼NW¼ Sec. 27, Paint Twp.

		Ft.	In.
Clay shale, slightly ferruginous		5	0
Limestone, gray, hard, dense, fossiliferous, platy, *Putnam Hill*		3	6
Clay shale, gray		0	2
Coal, shaly		0	2
Clay shale, dark	*Brookville*	0	2
Coal, fair	altitude 1,225 feet	1	3½
Clay, light gray, plastic, siliceous		8	0
Sandstone, white, micaceous, thin-bedded to shaly		10	0

4-207. SW up state road from crossroad ¾ mile N of Walnut Creek Twp. and 1⅝ miles E of Salt Creek Twp. to top of hill 100 yards W of Easley School, Paint Twp.

		Ft.	In.
Shale, siliceous; with ore balls		5	0
Coal smut, *Middle Kittanning*		0	4
Clay, light, siliceous, plastic		3	8
Shale, siliceous		4	4
Sandstone, massive, ganister-type		1	5
Shale, sandy		13	3
Shale, gray, clay-like		13	4
Covered, a few pieces of calcareous ore, *Hamden*		2	0
Coal, somewhat shaly		3	4
Shale, gray	*Lower Kittanning*	0	1½
Coal, fair		0	2
Clay, gray, siliceous, plastic		6	6
Clay shale, with ore balls up to 4 inches in diameter		13	11
Limestone, dove gray, hard, dense, fossiliferous; somewhat irregular and platy, *Putnam Hill,* altitude 1,160 feet		2	8
Clay shale, dark gray		0	3
Shale, black, coaly		0	1
Clay shale, gray	*Brookville*	0	1½
Coal, fair		0	2
Clay, gray, plastic		4	0
Shale, light, sandy		10	0
Shale, and covered		37	4
Creek level.			

5-227. In ravine N from Walnut Creek-Paint Twp. line and in mine of J. W. Dowalter and Alfred Flinter on farm of Samuel Troyer, ¾ mi. E of Salt Creek Twp. and ¾ mi. SW of Easley School, Paint Twp. (The highest three measurements are reported by the mine operators from drill records.)

		Ft.	In.
Sandstone		10	0
Coal, *Middle Kittanning*		0	6
Shale, siliceous to clay-like		31	0
Shale, dark, carbonaceous, fossiliferous; some fossils are pyrite, *Hamden* horizon		2	0
Shale, coaly		0	2
Coal, good	*Lower*	1	10
Pyrite (not continuous)	*Kittanning*	0	½
Coal, good		0	9

		Ft.	In.
Pyrite		0	¾
Clay, dark, carbonaceous, sandy, hard		0	4
Clay, sandy, hard, (thickness undetermined); shale, siliceous; and covered		20	0
Clay shale, slightly ferruginous		20	0
Limestone, blue gray, hard, dense, fossiliferous, *Putnam Hill*, altitude 1,155 feet		2	10
Clay shale, gray		0	2
Coal, shaly		0	½
Clay shale, dark gray	*Brookville*	0	1½
Coal, shaly		0	2
Clay, gray, plastic, siliceous		4	0
Sandstone, light, shaly; and covered		6	0
Shale, sandy		20	0

6-205. From valley bottom N along road ¼ to ½ mi. N of Walnut Creek Twp. line 1 mi. NW of Trail, S Paint Twp.

	Ft.	In.	
Shale and covered	20	0	
Coal blossom, *Lower Freeport*	0	8	
Clay and covered	5	0	
Shale, sandy; and covered	51	8	
Coal blossom, *Middle Kittanning*	0	8	?
Clay and covered	4	0	
Covered	19	6	
Coal, shaly, weathered, *Lower Kittanning*	0	6	0
Clay, sandy, light, siliceous	4	0	9
Clay shale and covered	12	0	6
Limestone, loose pieces, *Putnam Hill*	0	6	3
Coal blossom, *Brookville*	1	0	-0
Clay and covered	5	0	
Shale and covered	55	6	
Coal, poor, weathered, *Bedford*	1	2	
Clay, impure	1	10	
Shale, sandy	3	0	
Shale, dark, hard, carbonaceous, *Upper Mercer*	1	0	
Clay shale and covered	13	0	
Limestone, blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,110 feet	2	0	
Coal, clay; and covered, *Middle Mercer*	2	0	

7-199. Up road N from crossroad in Trail, central N Walnut Creek Twp. to central S Paint Twp.

		Ft.	In.
Shale, sandy		5	0
Shale, black, hard, bony		1	1
Clay shale, gray	*Upper Mercer*	0	3
Shale, black, hard, bony		0	4
Clay, impure; and covered		2	0
Clay shale, gray; some dark streaks		9	10
Limestone, blue, hard, dense, fossiliferous, *Lower Mercer*		1	8
Coal smut, clay; and covered, *Middle Mercer*		1	0

	Ft.	In.
Clay, gray, plastic	5	4
Shale, sandy	20	4
Shale, siliceous	22	8
Covered	16	0

Crossroad, Trail, altitude 1,011 feet.

8-206. W along road ¾ mi. W of Winesburg, Paint Twp.

	Ft.	In.
Covered	8	0
Clay, and covered, *Middle Kittanning*	3	0
Covered	9	0
Sandstone, thin-bedded	15	0
Sandstone, sandy shales; and covered	26	0
Coal, old mine, *Lower Kittanning,* altitude 1,213 feet	3	0
Clay, and covered	5	0
Drift covered	55	0

Stream level.

9-196. S along road from valley floor of Indian Trail Creek 1 mile W of the Holmes-Tuscarawas county line, SE Paint Twp.

		Ft.	In.
Clay shale, only slightly ferruginous		18	0
Limestone, blue gray, fossiliferous, platy, *Putnam Hill*		1	0
Clay, light, plastic; and covered, *Brookville*		5	4
Sandstone, white, shaly		6	0
Shale, sandy		15	4
Shale, dark, carbonaceous		0	1½
Clay, gray, plastic		0	4
Shale, sandy		2	8
Shale, dark, *Tionesta*		0	2
Clay, light, plastic		3	4
Shale, light, sandy		5	0
Shale, sandy		19	4
Clay shale, ferruginous		2	9
Coal, poor, shaly	*Bedford,* altitude 1,075 feet	0	3
Clay shale, gray		0	6
Shale, coaly		0	4
Clay shale, gray		0	8
Coal, shaly		0	5
Clay, gray, plastic		3	4
Shale, sandy		4	5
Sandstone, shaly		2	0
Shale, black, carbonaceous, *Upper Mercer*		1	2
Clay, sandy, impure		3	6
Clay shale, grading upward to siliceous shale		11	0
Limestone, granular, ferruginous, almost ore	*Lower Mercer*	1	0
Limestone, gray blue, hard, fossiliferous, slightly granular		3	2
Coal smut and covered, *Middle Mercer*		1	0
Clay, gray, plastic, siliceous		3	0

	Ft.	In.
Clay and covered	3	10
Shale, siliceous	24	0
Sandstone, light, shaly	12	0

Valley floor of Indian Trail Creek, altitude 1,000 feet.

10-198. Along road S of Indian Trail Creek ¼ to 1/16 mi. east of county line, Wayne Twp., Tuscarawas Co.

	Ft.	In.
Coal, weathered, *Middle Kittanning*	1	8
Clay, light, plastic, siliceous	11	4
Sandstone, light, thin-bedded	3	0
Covered; much *Lower Kittanning* clay	36	0
Shale, clay-like, somewhat ferruginous	10	0
Limestone and covered, *Putnam Hill*	2	0
Clay shale, gray	0	2
Coal, shaly, *Brookville*	0	2
Clay, gray to light, plastic, good	6	0
Covered	3	0
Shale, siliceous	18	0
Shale, in large part covered	48	0
Limestone, blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,050 feet	3	6
Coal smut; and covered, *Middle Mercer*	1	0
Clay and covered	2	0
Clay shale, with ore balls	8	0

10A-209. E up road from roadfork ⅓ mi. E of Holmes Co. and 1 mi. N of Indian Trail Creek, Wayne Twp., Tuscarawas Co.

	Ft.	In.
Clay shale	5	8
Shale, dark, carbonaceous, *Lower Kittanning*	2	2
Clay, impure	3	0
Clay shale, ferruginous	12	5
Limestone, (poorly exposed), gray, dense, hard, fossiliferous, *Putnam Hill*, altitude 1,105 feet	2	0
Coal blossom, *Brookville*	0	6
Clay, gray to light, sandy, plastic	5	1
Shale, light, sandy	6	0
Shale, siliceous	23	2
Covered	10	4
Limestone, gray blue, hard, dense to granular, fossiliferous, *Lower Mercer*	0	8
Clay, and covered	2	0
Covered	7	0
Sandstone, massive, *Massillon*	10	0

11-233. E up road from 1,163 roadfork ⅛ mi. from Paint Twp. line and ¼ mi. S of Greenville Treaty Line, NW Wayne Twp., Tuscarawas Co.

		Ft.	In.
Clay shale		0	9
Coal blossom, *Middle Kittanning*		1	9
Clay, impure		3	0
Clay shale		9	0
Shale, sandy; with 2-inch to 6-inch sandstone layers		5	0
Sandstone, massive; irregularly bedded		5	8
Clay shale, ferruginous and carbonaceous, *Hamden*		1	0
Coal (very little), clay, and covered, *Lower Kittanning*		5	0
Clay, light gray, plastic		7	4
Shale, siliceous, slightly ferruginous; and covered		39	11
Limestone, *Putnam Hill*		1	0
Clay shale, gray		0	3
Coal, shaly	*Brookville*	0	1
Clay shale, dark	*Brookville*	0	2
Coal, fair	*Brookville*	0	11
Clay, and covered		4	0
Sandstone, white, shaly, and covered		10	7
Roadfork, elevation 1,163 feet.			

STRATIGRAPHIC SECTIONS FROM SALT CREEK TOWNSHIP

11A-327. In local mine NE¼NW¼NE¼ Sec. 33, thence SE to quarry on hilltop in NE¼NE¼ Sec. 33, Salt Creek Twp.

		Ft.	In.
Shale, clayey, with small ore balls		10	0
Limestone, gray, with slightly brownish tinge, dense, fossiliferous, platy; weathered in 3- to 4-inch blocks, *Putnam Hill*		3	6
Covered		44	3
Limestone, black, irregularly fractured, flinty, fossiliferous	*Upper Mercer*	2	6
Limestone, dark blue, fossiliferous	*Upper Mercer*	0	9
Shale, carbonaceous		0	1½
Coal	*Bedford*, altitude 1,170 feet	0	7½
Shale, carbonaceous	*Bedford*, altitude 1,170 feet	0	1½
Coal, good	*Bedford*, altitude 1,170 feet	1	3
Clay, sandy, impure	*Bedford*, altitude 1,170 feet	1	1
Sandstone, white, clay-bonded	*Bedford*, altitude 1,170 feet	0	3
Clay, carbonaceous	*Bedford*, altitude 1,170 feet	0	5
Coal, good	*Bedford*, altitude 1,170 feet	0	11
Coal, bony	*Bedford*, altitude 1,170 feet	0	4
Coal, shaly, hard	*Bedford*, altitude 1,170 feet	0	11

12-138. N along road from NE¼NE¼NW¼ Sec. 5 to top of hill in SE¼SW¼ Sec. 32, NW Salt Creek Twp.

	Ft.	In.
Shale, sandy	3	0
Coal smut, *Lower Kittanning*	0	3
Clay, white, siliceous	6	0
Clay shale, with ore balls; a little covered	17	0
Limestone, gray, dense, fossiliferous, *Putnam Hill*, altitude 1,230 feet	3	6
Coal blossom, *Brookville*	1	6

	Ft.	In.
Clay, white, plastic	5	6
Sandstone, white	3	0
Shale, sandy, and covered	10	0

13-59. E along road SE¼NW¼ Sec. 6, W Salt Creek Twp.

	Ft.	In.
Clay and covered		
Limestone, gray, *Putnam Hill,* altitude, 1,180 feet	4	0
Coal, weathered, *Brookville*	2	6
Clay, white, plastic	3	0
Sandstone, white, and covered	10	0
Shale, sandy, and covered	21	6
Flint, dark blue-black, fossiliferous, *Upper Mercer*	2	0
Coal, weathered, *Bedford*	3	6
Clay, dark	0	6
Clay, light, plastic	2	0
Clay shale, and covered	8	0

14-13. S up road from Prairie-Salt Creek twp. line to hilltop ¼ mi. N of Hardy Twp. and ¼ mi. E of Prairie Twp., SW Salt Creek Twp.

	Ft.	In.
Shale, and covered	8	0
Coal, weathered, *Lower Kittanning*	2	0
Clay, good	5	3
Clay, and covered	6	9
Covered	14	0
Limestone, and covered, *Putnam Hill,* altitude 1,185 feet	4	0
Coal blossom, *Brookville*	2	0
Covered	12	6
Clay, white, good, *Tionesta*	4	0
Sandstone, shaly	18	6
Covered	8	0
Coal, weathered, *Bedford*	1	0
Clay	1	0
Covered	26	9
Limestone, dark, hard, massive, *Lower Mercer*	1	0
Clay, dark, carbonaceous, *Middle Mercer* coal horizon	0	8
Clay, white	4	11
Coal, shaly, weathered, *Flint Ridge*	0	8
Clay, gray; carbonaceous streaks	1	0

15-236. N along road and in quarry of Eli E. Mullet, NE¼SW¼ Sec. 3, Salt Creek Twp.

		Ft.	In.
Drift and disturbed shale		8	0
Limestone, blue, crystalline, ferruginous, weathers brown, very fossiliferous	*Putnam Hill,* altitude 1,220 feet	0	3
Limestone, gray blue, more irregularly bedded than lower bench		2	9
Limestone, blue gray, massive, fossiliferous		2	5

		Ft.	In.
Clay, gray		0	2
Coal, fair to shaly	*Brookville*	0	9
Coal, dark	*Brookville*	0	1
Coal, bright, blocky	*Brookville*	0	11
Clay, light gray, plastic, good		3	0
Clay, and covered		4	9
Shale, white, sandy		12	0
Shale, siliceous		20	6
Clay shale, and covered		3	0
Coal blossom, *Bedford*		1	6
Clay, sandy, impure		2	0

STRATIGRAPHIC SECTIONS FROM PRAIRIE TOWNSHIP

16-54. W up ravine and lane from NE¼NE¼SW¼ to NW¼SW¼ Sec. 25, Prairie Twp.

	Ft.	In.
Clay shale, grayish green, with iron concretions	5	6
Coal blossom, *Lower Kittanning*	0	3
Clay, gray, impure	4	6
Clay, pink mottled, almost red	0	6
Clay, light, plastic	0	8
Shale, siliceous, iron stains	2	0
Shale, sandy	8	0
Shale and covered	19	6
Limestone, gray, dense, fossiliferous, *Putnam Hill,* altitude 1,150 feet	3	0
Coal, old mine, *Brookville*	3	0
Covered	35	10
Limestone, dark blue, hard, fossiliferous, flinty, *Upper Mercer*	3	0
Coal, good, old mine, *Bedford*	2	6
Covered	17	0
Shale, siliceous	3	0
Coal, good, *Upper Mercer?*	0	9
Shale, sandy	8	9
Clay shale, dark	0	7
Clay shale, gray	3	5
Coal, shaly, *Flint Ridge?*	0	6
Clay, dark, micaceous, with plant fossils, very impure, sandy	3	0
Clay shale, light gray	2	0
Shale, sandy	10	0
Sandstone	19	0
Covered with rubble and drift.		

17-72. NW from mouth of ravine in SE¼NE¼ Sec. 1 to top of hill in SE¼ NW¼NE¼ Sec. 1, Prairie Twp.

Pennsylvanian system

		Ft.	In.
Flint, dark to tan, very fossiliferous	*Upper Mercer*	0	10
Limestone, weathered to clay	*Upper Mercer*	1	1
Flint, black, fossiliferous	*Upper Mercer*	3	3
Coal, weathered, *Bedford*		3	4
Covered		97	0

		Ft.	In.
Shale, dark, carbonaceous, *Bear Run* horizon		1	0
Shale, sandy		4	0
Ore, blue gray to tan, fine-grained, calcareous, not nodular		0	5
Shale, sandy		0	8
Coal, shaly		0	4
Clay shale		0	1½
Coal, bright, hard		0	8
Shale, black, hard, bone	*Quakertown,*	0	3
Shale, black, carbonaceous	altitude	1	0
Shale, dark, carbonaceous, with ore balls	1,000 feet	1	6
Shale, black, hard, bone		1	0
Coal, bony		0	5
Shale, gray to black, hard		0	7
Covered		4	4
Shale, dark gray, clay-like; with ore balls 2 inches to 5 inches		1	6
Shale, sandy		1	0
Ore, impure, sandy, discontinuous, *Harrison*		0	2

Mississippian system

	Ft.	In.
Sandstone, massive to 2-inch beds	16	0
Shale, gray, siliceous	4	0
Sandstone, thin-bedded to massive	17	0

18-71. NW up ravine SW¼NE¼ Sec. 1, E Prairie Twp.

	Ft.	In.
Flint, black, *Upper Mercer*	5	2
Coal, weathered, *Bedford*	3	4
Covered	54	0
Sandstone, light yellow, quartzitic	4	0
Sandstone, white, clay-bonded; with a few plant fossils	4	0
Coal, hard, bright, cannel, *Vandusen*	0	6
Clay, grayish white, sandy; with plant fossils	2	0
Covered	13	0
Shale, dark, carbonaceous, soft	3	0

19-238. SE along road from central partial Sec. 16 to top of hill, S Prairie Twp.

		Ft.	In.
Clay shale, with small ore balls		20	0
Limestone, gray, hard, dense, fossiliferous, 2- to 3-inch slabs, *Putnam Hill*		2	6
Clay and covered, *Brookville*		12	0
Shale, siliceous to sandy		27	4
Clay shale		5	10
Coal, clay shale, and covered		5	6
Clay shale	*Bedford*	1	0
Coal, shaly		1	4
Coal, weathered		1	3
Clay, impure, and clay shale		4	0
Shale, sandy		10	5
Covered and sandstone; mainly covered		68	0
Sandstone, irregularly bedded, fairly massive		11	4
Sandstone, massive		3	0
Shale, siliceous, with ore balls		5	4

	Ft.	In.
Shale, dark gray, carbonaceous, *Quakertown*	1	0
Sandstone, white, ganister-type	5	0
Covered (drift)	33	8
Road fork, altitude 930 feet.		

20-47. In bank of Colliers Run and N up road to hilltop in E½ partial Sec. 14, ¼ mi. SSW of Hammond School, SE Prairie Twp.

	Ft.	In.
Pennsylvanian system		
Limestone, dark blue, hard, flinty, fossiliferous, *Upper Mercer*	1	0
Coal, weathered, *Bedford*	3	6
Clay, light, plastic	3	0
Shale, and covered	26	6
Limestone, loose blocks, *Lower Mercer*	0	6
Coal, clay; and covered, *Middle Mercer*	2	6
Covered	8	0
Coal, clay; and covered, *Flint Ridge*	2	0
Covered	46	0
Sandstone	1	0
Clay and covered	2	0
Clay shale, ferruginous	3	0
Shale, dark, carbonaceous, *Quakertown,* altitude 970 feet	2	2
Clay, impure	4	8
Sandstone, white, clay-bonded	3	2
Clay shale	2	0
Shale, sandstone, and covered	61	8
Sandstone, shaly	5	0
Clay shale, light	0	2
Shale, sandy	4	0
Shale, black, carbonaceous (base of Pottsville)	1	0
Mississippian system		
Shale, sandy, and sandstone, shaly, *Vinton*	10	0

21-48. Along N-S road in NW partial Sec. 13 and SW¼SW¼ Sec. 12, Prairie Twp.

	Ft.	In.
Coal, clay; and covered, *Bedford*	1	0
Covered	17	0
Limestone, blue, hard, *Lower Mercer,* altitude 1,060 feet	1	0
Coal, clay; and covered, *Middle Mercer*	3	0
Sandstone, clay-bonded; and covered	16	6
Shale, siliceous	2	0
Coal, shaly, *Lower Mercer*	0	10
Sandstone, thin-bedded	9	8
Shale, gray, siliceous	0	6
Shale, black, carbonaceous, *Vandusen*	1	8
Shale, sandy	8	0

STRATIGRAPHIC SECTIONS FROM RIPLEY TOWNSHIP

20A-353. Along road SW¼SW¼SE¼ Sec. 1, Ripley Twp.

	Ft.	In.
Sandstone, weathered, somewhat coarse	6	0
Coal, weathered, *Bedford*	0	3
Sandstone, yellow brown, fairly coarse	11	11
Ore, weathered	0	5
Limestone, blue, hard, fossiliferous, *Lower Mercer*, altitude 1,150 feet	1	1
Clay and covered, *Middle Mercer*	5	0
Shale, sandy; and covered	22	8
Coal smut, *Lower Mercer*	1	0

22-357. W along road in central Sec. 8, SW Ripley Twp.

	Ft.	In.
Soil; a few glacial pebbles; clay; coal smut; and covered, *Brookville*	5	0
Sandstone, white, thin-bedded, clay-bonded, micaceous	15	4
Clay shale	0	10
Clay shale, with ore balls	0	6
Clay shale, light	2	4
Coal, weathered, *Tionesta*, altitude 1,260 feet	0	10
Clay, white, sandy; and covered	2	0
Sandstone, white, thin-bedded, clay-bonded; containing muscovite	7	6

23-245. E along road SE¼SE¼ Sec. 2, E Ripley Twp.

	Ft.	In.
Shale, sandy	20	0
Limestone, loose pieces; blue, hard, dense, fossiliferous, *Lower Mercer*	0	6
Shale, carbonaceous to coaly, *Middle Mercer* horizon	0	6
Clay, light, plastic, siliceous	6	0
Shale and covered	16	0
Shale, siliceous	15	0
Shale, black, carbonaceous, *Lower Mercer*	2	6
Shale, gray, clayey	1	0
Covered	11	0

Level of small stream, altitude 1,115 feet.

STRATIGRAPHIC SECTIONS FROM KNOX TOWNSHIP

25-396. NW in ravine from 1 mi. W of Monroe Twp. line and 1⅝ mi. S of Ripley Twp. line to coal stripping at top of 1400-foot knob, Knox Twp.

		Ft.	In.
Till, contains mainly sandstone		6	0
Sandstone, coarse, irregular		4	0
Shale, black, carbonaceous		8	0
Coal, good	*Middle Kittanning*	0	7
Shale, pyritiferous	*Middle Kittanning*	0	0½
Coal, good	*Middle Kittanning*	1	7
Shale, pyritiferous	*Middle Kittanning*	0	0½
Coal, good	*Middle Kittanning*	1	5

		Ft.	In.
Clay, plastic		2	0
Covered		81	2
Limestone, gray, large loose blocks, *Putnam Hill*		2	0
Covered		5	0
Shale and covered		26	4
Sandstone, white, clay-bonded, hard		1	0
Flint, black, *Upper Mercer*		1	3
Shale, black, carbonaceous	*Bedford*	0	3
Coal, bright, with thin cannel streaks	*Bedford*	0	6
Coal, cannel, with thin bituminous streaks	*Bedford*	0	11
Shale, black, carbonaceous	*Bedford*	0	1
Clay, gray, plastic, with carbonaceous streak		3	6
Shale, blue gray, siliceous to sandy		6	8
Shale, black, canneloid	*Upper Mercer*	0	7
Coal, bright, blocky	*Upper Mercer*	0	5
Clay, gray, hard, sandy		1	0
Sandstone, white, clay-bonded, hard		0	8
Shale, light gray, siliceous		1	8
Clay shale, dark gray, carbonaceous		3	4
Sandstone, fine-grained, carbonaceous		0	8
Shale, gray, sandy		7	8
Shale, with coaly streaks	*Flint Ridge*	2	0
Coal, shaly	*Flint Ridge*	1	4
Sandstone, coarse, massive		22	0
Covered		2	10
Shale, black, carbonaceous; and cannel coal; poorly exposed, *Quakertown*		2	6
Shale, light gray, siliceous		2	0
Covered		10	0

Fork of main ravine.

26-324. E up ravine ¾ mi. W of Monroe Twp. line, 2 mi. S of Ripley Twp. line, and ¼ mi. W of 1303 road fork, to coal stripping on hilltop SE of road fork, Knox Twp.

		Ft.	In.
Clay shale, slightly ferruginous		6	0
Shale, hard, carbonaceous		1	6
Coal, bony	*Middle Kittanning*	0	7
Coal, bright	*Middle Kittanning*	3	6
Clay, plastic		4	0
Sandstone and covered		41	11
Sandstone, massive		8	0
Sandstone, shaly		4	0
Limestone, gray to tan, dense, ferruginous	*Putnam Hill*, altitude 1,275 feet	0	6
Limestone, gray, dense	*Putnam Hill*, altitude 1,275 feet	1	7
Coal, good, mined, *Brookville*		2	0
Covered		35	0
Clay shale, gray		1	0
Coal, bright, *Tionesta?*		0	9

		Ft.	In.
Clay, sandy		0	11
Sandstone, thin-bedded, clay-bonded		1	6
Shale, sandy, carbonaceous	*Bedford*	0	5
Clay shale, pyritiferous	*Bedford*	0	8
Coal, shaly	*Bedford*	0	4
Coal, fair to bony	*Bedford*	0	5
Clay, light, siliceous		1	3
Shale, carbonaceous, *Upper Mercer*		4	5
Covered		11	4
Limestone, shaly	*Lower Mercer*	0	2
Limestone, dark blue, 1 massive ledge, fossiliferous, dense	*Lower Mercer*	3	1
Covered		3	4
Clay shale, gray		11	4
Clay shale, carbonaceous, *Flint Ridge*		2	3

27-271. In a ravine NW of road fork ¼ mi. WNW of Bell Ridge School, ¾ mi. W of Monroe Twp. line, and 2 mi. N of Richland Twp. line, Knox Twp.

Sandstone and covered	8	0
Sandstone, massive	10	0
Covered	2	0
Clay, light, siliceous, plastic, *Brookville?*	4	0
Shale, sandy; and covered	39	0
Covered	10	0
Shale, siliceous	10	0
Shale, dark, carbonaceous, somewhat sandy, hard, *Bedford*	4	2
Clay shale, dark gray	1	0
Shale, siliceous to sandy	10	0
Shale, clay-like	8	8
Limestone, more shaly than usual, *Lower Mercer,* altitude 1,195 feet	1	8
Covered	1	6
Carbonaceous shale, black, hard, *Middle Mercer*	2	0
Covered	2	0
Shale, gray, clay-like	10	0

28-332. N up road from ¼ mi. N of section line to hilltop in NW¼ E½ partial Sec. 15, Knox Twp.

Pennsylvanian system	Ft.	In.
Shale, sandy, slightly ferruginous	4	0
Limestone, dark blue, hard, slightly granular, fossiliferous, *Lower Mercer,* altitude 1,280 feet	1	6
Clay and clay shale; all somewhat ferruginous and weathered	10	0
Sandstone, shaly	4	0
Coal smut; and covered, *Flint Ridge*	1	0
Covered	1	4
Clay, gray to yellow, siliceous, plastic, weathered	6	4
Sandstone, thin-bedded	9	8
Covered	5	0
Sandstone, thin-bedded	8	0
Shale, slightly ferruginous	3	10

	Ft.	In.
Shale, black, carbonaceous, *Bear Run*	1	3
Clay, impure	2	0
Sandstone and covered	13	11
Covered	3	0
Mississippian system		
Sandstone, thin-bedded; with iron spots; rather soft, fine-grained	16	0

29-333. In road cut of Nashville-Greer road, NW¼NE¼ Sec. 16, W Knox Twp.

	Ft.	In.
Clay shale, ferruginous	4	0
Limestone, dark blue, hard, dense, fossiliferous, *Lower Mercer*	2	8
Coal, fair, *Middle Mercer*	0	4
Clay, gray, plastic	3	0
Clay shale, ferruginous	2	4
Coal, fair, *Flint Ridge*, altitude 1,290 feet	0	1½
Clay, gray	1	3
Clay, very sandy and impure	3	4
Sandstone, clay-bonded, iron-stained	1	0
Clay, gray, siliceous, *Lower Mercer*	5	6

30-320. Along a road ⅛ mi. E of partial Sec. 13, 2½ mi. S of Nashville, Knox Twp.

	Ft.	In.
Limestone, dark blue, hard, dense to slightly granular, *Lower Mercer*, altitude 1,260 feet	3	0
Shale, carbonaceous; and covered, *Middle Mercer*	1	6
Clay, light, siliceous to sandy	10	2
Shale, ferruginous, siliceous	0	6
Shale, carbonaceous, *Flint Ridge*	0	10
Clay, sandy, somewhat micaceous	2	6
Sandstone, light, clay-bonded, thin-bedded, micaceous	4	0

31-319. SW and S up road 2½ mi. S of Nashville and ¼ mi. E of partial Sec. 13, Knox Twp.

	Ft.	In.
Pennsylvanian system		
Shale, siliceous, grading upward into sandy shale	9	0
Shale, siliceous, ferruginous	3	0
Limestone, dark blue, hard, dense to slightly granular, fossiliferous, *Lower Mercer*, altitude 1,240 feet	2	6
Shale, coaly; and covered, *Middle Mercer*	1	0
Clay, light, plastic	4	2
Shale and covered	16	6
Shale, siliceous	8	0
Coal blossom, *Lower Mercer*	0	3
Clay, light, siliceous	1	7
Clay shale, gray	0	6
Ore, irregular and nodular } *Poverty Run*	0	1
Shale, ferruginous } *Poverty Run*	0	3
Shale, carbonaceous, *Vandusen*	0	2

		Ft.	In.
Clay, dark gray	*Vandusen*	0	6
Clay, light, plastic	*Vandusen*	6	6
Shale, siliceous		6	7
Clay shale, gray		1	8
Coal blossom, *Bear Run*		0	7
Clay, light, plastic		3	6
Sandstone, light, somewhat massive		6	8
Coal blossom, *Quakertown*		0	6
Clay and covered		3	2
Mississippian system			
Sandstone, olive, thin-bedded; top 3 feet iron-stained		15	0
Sandstone and covered		40	0

32-318. Along road ¼ mi. N of Richland Twp. line, 2 mi. WNW of Glenmont, Knox Twp.

Flint, black, weathered, loose pieces, *Upper Mercer*		0	6
Covered		15	0
Shale		5	0
Ore, reddish tan, loose pieces, dense, very hard		0	6
Limestone, blue black, argillaceous, not very shaly	*Lower Mercer*	1	6
Limestone, very dark, blue, hard, dense fossiliferous	*Lower Mercer*	2	0
Clay, and covered, *Middle Mercer*, altitude 1,240 feet		4	10
Sandstone, light, irregular, thin-bedded to shaly, somewhat micaceous, clay-bonded		23	0
Covered, mainly sandstone		25	0
Sandstone and covered, *Massillon*		78	0
Sandstone and covered		10	0

STRATIGRAPHIC SECTIONS FROM MONROE TOWNSHIP

33-316. S along road to road fork ¼ mi. S of Millersburg-Loudonville road 2½ mi. W of Hardy Twp. line, Monroe Twp.

Limestone, gray, hard, dense, fossiliferous, platy, *Putnam Hill*, altitude 1,220 feet	2	6
Coal smut, clay; and covered	1	0
Clay, light, plastic, siliceous	3	2
Sandstone, white, clay-bonded, micaceous, thin-bedded	6	2
Sandstone, thin-bedded, micaceous to shaly	11	4
Clay shale, gray	0	4
Coal, shaly, weathered, *Tionesta*	0	3
Clay, gray, sandy	2	8
Shale, sandy	10	0

34-324A. In ravine S of road, ⅛ mi. E of Knox Twp. and 2½ mi. N of Richland Twp., W Monroe Twp.

Flint, black, loose pieces, *Upper Mercer*	0	6
Coal blossom, *Bedford*	1	2
Clay and covered	3	2

		Ft.	In.
Clay shale		9	6
Limestone, granular, shaly, somewhat ferruginous	Lower Mercer, altitude 1,180 feet	0	2
Limestone, dark blue, hard, dense, massive, fossiliferous		3	3
Clay, *Middle Mercer*		2	0
Clay shale		3	0

35-358A. N in deep ravine W of road, 2¼ mi. N of Richland Twp. and ½ mi. E of Knox Twp., extending NNE across road to old Middle Kittanning coal mine near hilltop, W Monroe Twp.

		Ft.	In.
Coal, mined, *Middle Kittanning* altitude 1315 feet		4	0
Covered		30	0
Sandstone, coarse, massive, cross-bedded, weathers into large blocks; makes steep cliff at head of ravine		32	0
Covered		23	0
Shale, gray, siliceous		6	3
Shale and covered		3	0
Limestone, very dark blue, granular, with black flint masses and lenses, *Upper Mercer*		3	9
Coal, old mine, (reported thickness), *Bedford*		2	10
Covered		5	10
Clay, dark gray, carbonaceous, sandy, *Upper Mercer* horizon		4	0
Shale, gray, siliceous to sandy		7	6
Limestone, gray blue to blue, fine granular; one solid ledge, *Lower Mercer*		4	1
Shale, black, carbonaceous, sandy, *Middle Mercer*		0	6
Clay, impure		1	0
Shale, gray blue, fine-grained		1	11
Shale, black, carbonaceous, hard	*Flint Ridge*	1	6
Coal, bright, blocky, good		1	2
Clay shale, gray		0	6
Shale, black, with coaly streaks		1	0
Coal, cannel		0	8
Clay shale, gray		0	11
Coal, shaly, cannel		0	2
Coal, bright, blocky		0	6
Shale, black, bony, canneloid		0	5
Clay, very impure		1	6
Sandstone, thin-bedded		3	10
Ore, very sandy, irregular, *Boggs*		0	5
Clay shale		1	0
Shale, dark gray, carbonaceous	*Lower Mercer*	1	3
Shale, black, carbonaceous, sandy, somewhat ferruginous		1	6
Clay, sandy, impure		1	6
Shale, bluish gray to dark gray, fine-grained		3	2
Ore, gray to tan, massive, sandy, irregular ledge, *Poverty Run*		0	10
Shale and covered		3	0
Ore, tannish gray, single ledge, irregular		0	9

	Ft.	In.
Sandstone, white, shaly	1	3
Sandstone, coarse, cross-bedded; includes some shaly sandstone interbedded, *Massillon*	24	0

36-313. NE up ravine ¾ mi. E of Knox Twp. and 1⅝ mi. N of Richland Twp., W Monroe Twp. Quakertown coal in mine of Clayton Rizer and Walter Lewis on farm of John Armstrong.

Pennsylvanian system

		Ft.	In.
Shale, sandy; sandstone; and covered		31	1
Coal blossom, *Lower Kittanning?*		1	3
Clay and covered		8	0
Sandstone and covered		99	4
Sandstone, thin-bedded to shaly		19	6
Ore, thin-bedded to shaly, siliceous; with plant fossils	*Poverty Run*	0	6
Shale, gray blue to dark	*Poverty Run*	2	8
Ore, dark, hard, massive, ranges from 2 to 8 inches	*Poverty Run*	0	6
Shale, gray		0	6
Coal, bony, *Vandusen*		0	3
Clay, sandy; with plant fossils		2	3
Sandstone, massive		3	6
Covered and shale		5	0
Shale, gray; in part carbonaceous		5	0
Coal, fair, *Bear Run*		0	7
Sandstone, light, clay-bonded		2	10
Sandstone, massive		3	0
Coal, bony	*Quakertown,* altitude 1,100 feet	0	3
Coal, fair	*Quakertown,* altitude 1,100 feet	0	4½
Shale, dark, carbonaceous	*Quakertown,* altitude 1,100 feet	0	½
Coal, good	*Quakertown,* altitude 1,100 feet	0	4
Shale, black, carbonaceous, soft	*Quakertown,* altitude 1,100 feet	0	1½
Coal, good	*Quakertown,* altitude 1,100 feet	1	2
Clay, dark gray, carbonaceous, very sandy		0	4
Sandstone, clay-bonded, hard, massive		3	0
Covered		2	0

Mississippian system

	Ft.	In.
Sandstone, thin-bedded	18	0
Fork of ravine		

37-255. E up road to 1,190 crossroad 1 mi. SW of Welcome and ⅝ mi. N of Killbuck Twp. line, Monroe Twp.

Pennsylvanian system

	Ft.	In.
Shale, clayey, with small ore balls	10	0
Limestone, gray, dense, *Putnam Hill,* altitude 1,196 feet	3	10
Clay shale, gray	0	4
Coal blossom, *Brookville*	2	6
Clay, light gray, plastic, siliceous	9	6
Shale, white, sandy, micaceous	17	6
Shale and covered	14	2

	Ft.	In.
Shale, coaly, *Tionesta*	0	5
Clay, sandy	1	0
Shale, light, sandy	12	0
Shale and covered	23	1
Coal blossom, *Bedford*	0	6
Clay and covered	3	0
Shale, siliceous to sandy	7	0
Covered	2	10
Coal blossom, *Middle Mercer?*	0	6
Clay and covered	3	0
Covered	20	10
Sandstone and covered, *Massillon*	40	0
Covered	3	0
Mississippian system		
Sandstone, thin-bedded; and covered, *Vinton*	100	0

38-322. S along road ⅞ mi. S of state road and 1½ mi. NNW of Welcome, Monroe Twp.

	Ft.	In.
Shale, sandy	31	0
Shale, clayey; and covered	2	6
Coal, shaly } *Bedford*, altitude 1,155 feet	0	3
Clay shale, gray } *Bedford*, altitude 1,155 feet	0	4
Coal, shaly } *Bedford*, altitude 1,155 feet	1	2
Clay, sandy	3	0
Sandstone, white, thin-bedded, clay-bonded	2	5
Shale, black, carbonaceous, *Upper Mercer* coal horizon	0	7
Clay, very sandy, micaceous, hard	1	6
Shale, sandy	5	0

39-248. NE along abandoned road 1 mi. NNE of Welcome, Monroe Twp.

	Ft.	In.
Limestone, loose pieces, *Putnam Hill*	0	3
Coal blossom, *Brookville*	0	8
Sandstone, white; clay; and covered	13	0
Shale, sandy	21	0
Shale, sandy; a few small ore balls	17	4
Coal, weathered, shaly, *Bedford*	0	10
Clay, impure	2	5
Shale, white, siliceous; grading into clay, buff	4	0
Clay, carbonaceous; shale; and covered, *Upper Mercer* horizon	1	0
Shale, siliceous	19	9
Limestone, dark blue, hard, dense, fossiliferous, *Lower Mercer*	3	6
Covered	1	0
Clay shale	6	10
Shale, carbonaceous, *Flint Ridge*	1	0
Clay	4	8
Coal blossom, *Lower Mercer*, altitude 1,070 feet	1	0
Clay and covered	6	8
Shale, siliceous	4	0
Shale, carbonaceous, *Vandusen*	0	6
Clay	1	6

	Ft.	In.
Shale, sandy	35	0
Sandstone	4	0
Ore, sandy, nodular	0	2
Shale, carbonaceous, (or coal?), blossom, *Bear Run*	0	4
Clay, white, plastic, siliceous	7	6
Sandstone, shaly	10	0

40-280. Record of water well drilled on farm of Homer Doty, 1 mi. ENE of Welcome, 1⅛ mi. W of Hardy Twp. and 1¾ mi. N of Killbuck Twp., E Monroe Twp. Record furnished by John McMillen, driller.

Well head, elevation 1,220 feet.

Pennsylvanian system		
Shale	20	0
Limestone, gray, (*Putnam Hill*)	5	0
Interval	83	0
Limestone, blue, (*Lower Mercer*)	4	0
Shale	20	0
Sandstone, (*Massillon*)	50	0
"Slate" (carbonaceous shale) and coal, (*Quakertown*)	5	0
Sandstone	5	6
Mississippian system		
Shale (shaly sandstone?) *Vinton.*		

STRATIGRAPHIC SECTIONS FROM HARDY TOWNSHIP

45-65. In road cut E and N of 1193 road fork in NW¼ Sec. 4, NE Hardy Twp.

Shale, sandy; with iron concretions	10	0
Clay shale, gray	2	6
Coal, weathered, *Lower Kittanning*	3	4
Clay, gray, plastic	6	2
Shale, and covered	15	4
Limestone, gray, *Putnam Hill*	4	3
Coal, weathered, *Brookville*, altitude 1,173 feet	2	0

46-63. E up road SW¼NE¼SE¼ Sec. 4, NE Hardy Twp.

Shale, sandy	5	0
Coal, weathered, *Lower Kittanning*	2	3
Clay, gray to light, plastic	6	5
Clay shale, with iron concretions	5	0
Iron concretions—prominent layer, oval to round, 1 to 5 inches, weathered concentrically, red brown to yellow	1	4
Clay shale, with iron concretions	7	8
Shale, dark red to brown, very ferruginous, weathered	0	7
Clay shale, dark gray	0	6
Clay shale, iron-stained	1	11
Limestone } *Putnam Hill,* altitude 1,195 feet	2	0
Covered; and limestone blocks } *Putnam Hill,* altitude 1,195 feet	4	0
Coal blossom, *Brookville*	2	0

	Ft.	In.
Clay, light, plastic	5	0
Shale, and covered	15	8
Coal blossom, *Tionesta*	0	4
Clay	1	0

47-51. S along road from Prairie Twp. line, NW partial Sec. 5, Hardy Twp.

	Ft.	In.
Limestone, gray blue, fossiliferous, *Putnam Hill,* altitude 1,150 feet	5	2
Clay shale	0	2
Coal } *Brookville*	1	1
Clay shale } *Brookville*	0	1
Coal } *Brookville*	0	6
Clay, plastic, good	3	0
Clay, and covered	3	0
Shale and covered	7	1
Sandstone, shaly	9	0
Shale and covered	19	0
Clay shale	2	0
Limestone, blue, hard, partially flinty, *Upper Mercer*	3	0
Coal, bony, weathered, *Bedford*	5	0

48-237. NW along road ¼ mi. NW of Oak Ridge School, 1 mi. NW of NW corner of Millersburg corporation line, Hardy Twp.

	Ft.	In.
Shale, sandy	15	0
Coal blossom, *Bedford*	1	0
Covered; clay; and sandstone, light	29	0
Sandstone, white, thin-bedded	5	0
Shale, slightly ferruginous	15	0
Shale, dark, carbonaceous, *Lower Mercer,* altitude 1,005 feet	2	0
Sandstone, thin-bedded; to shale, sandy	17	0
Shale, sandy; and covered	32	0
Shale, sandy	25	0
Shale, dark gray, calcareous; plant fossils	1	4
Clay shale	0	6
Covered	9	2
Sandstone; shale, sandy; and covered	40	0

49-239B. W up ravine ¾ mi. due W. of NW corner of Millersburg corporation line, Hardy Twp.

	Ft.	In.
Sandstone, shaly; and covered	2	0
Coal, and covered, *Flint Ridge*	1	0
Clay, siliceous, light	2	6
Shale	3	4
Sandstone, massive	2	6
Sandstone, shaly and irregular	4	8
Shale, dark, hard, carbonaceous, *Lower Mercer*	1	0
Shale, dark, sandy	5	0
Ore, dark, sandy, massive	1	0
Shale, sandy, ferruginous	7	0
Sandstone	4	0

	Ft.	In.
Coal, fair, *Vandusen*	0	7
Clay shale	6	0
Sandstone, *Massillon*	40	0

50-243. S along road ⅜ mi. NNW of Gambles School, 1 mi. S of Prairie Twp. and ⅞ mi. E of Monroe Twp., NW Hardy Twp.

Clay shale, slightly ferruginous	8	0
Limestone, hard, platy, dense, *Putnam Hill*	2	7
Clay shale	0	2
Coal blossom, *Brookville;* altitude 1,170 feet	0	5
Clay, light, plastic, siliceous	6	5
Shale, siliceous	11	6
Coal blossom, *Tionesta*	0	5
Clay shale	0	6
Clay, gray, siliceous	3	6
Shale, siliceous	20	0

51-242. Along road N from Loudonville road and N from Corns Run to top of hill ¼ mi. S of Gambles School, W Hardy Twp.

Clay shale, gray, ferruginous	3	0
Limestone, gray, dense, fossiliferous, *Putnam Hill*	2	0
Clay shale, gray	0	2
Coal blossom, *Brookville*	0	10
Clay, gray, plastic, siliceous; (partly obscured)	11	4
Shale, sandy	30	6
Coal blossom, *Tionesta*	0	2
Clay and covered	3	0
Shale, sandy, somewhat ferruginous	12	0
Coal, shaly, blossom, *Bedford*	0	6
Clay, impure	2	0
Shale, white, sandy	4	0
Shale, sandy	21	6
Limestone, gray blue, hard, dense, slightly granular, *Lower Mercer,* altitude 1,070 feet	0	8
Covered	4	0
Sandstone, and covered, *Massillon*	75	0

52-276. E along road, ¾ mi. E of Monroe Twp. and 1¾ mi. N of Killbuck Twp., Hardy Twp.

Covered	7	8
Coal, old mine, *Lower Kittanning*	3	0
Covered	23	4
Clay shale	5	0
Limestone, gray, dense, platy, fossiliferous, *Putnam Hill,* altitude 1,165 feet	4	8
Clay shale	0	3
Coal, shaly, weathered, *Brookville*	0	7
Clay, light gray, siliceous, plastic	7	0

53-277. NE along road, ¼ mi. E of Monroe Twp. and 1¾ mi. N of Killbuck Twp., E Hardy Twp.

	Ft.	In.
Coal, old mine, *Lower Kittanning,* altitude 1,205 feet	3	0
Covered	15	0
Shale, siliceous, slightly micaceous	14	0
Limestone, *Putnam Hill*	2	0
Clay, and covered	6	0
Sandstone, white, shaly	3	0

54-290. In abandoned Shevilard (Leasure) mine in Bedford coal ⅛ mi. N of Killbuck Twp. and 1⅛ mi. E of Monroe Twp., thence WNW up Hardy Run and across road to Donald Coal Co. mine in Middle Kittanning coal ⅜ mi. N of Killbuck Twp. and ¾ mi. E of Monroe Twp., SW Hardy Twp.

		Ft.	In.
Shale, black, hard, carbonaceous, ("slate")		1	6
Shale, slightly carbonaceous, siliceous		3	0
Shale, dark, hard, carbonaceous, ("slate")		1	9
Coal, cannel, bony	*Middle Kittanning,* elevation 1,200 feet	0	1½
Coal, cannel		0	3
Coal, bony, with pyrite, soot, etc., usually rejected		0	5½
"Dirt," soot streaks, rejected		0	⅜
Coal, with irregular soot streaks, usually rejected, ("soot band")		0	5½
Coal, fair		0	6½
"Dirt," (black soot streak, rejected)		0	1/16
Coal, blocky, good		1	7
Clay		0	4
Clay and covered		7	6
Sandstone, and covered		18	4
Old mine opening, *Lower Kittanning*		3	6
Covered		24	0
Clay shale, weathered		10	0
Limestone, very dark gray blue, hard, dense, fossiliferous, *Putnam Hill*		1	10
Clay shale and coal smut, *Brookville*		0	3
Clay, siliceous, plastic		3	9
Sandstone, white, contains coaly lenses		0	4
Sandstone, white, hard		0	5
Sandstone, white, thin-bedded, contains coaly lenses		0	4
Clay, very sandy		2	6
Shale, sandy		42	0
Shale, black, calcareous, extremely fossiliferous, *Upper Mercer* horizon		2	0
Coal, canneloid, shaly, once-mined	*Bedford*	7	1
Sandstone, white, clay-bonded, shaly; with carbonaceous streaks		1	4
Shale, black, carbonaceous, hard		3	0

55-401. Log of drill core drilled by BBR Drilling Corp. in March, 1947, for Ohio State University Engineering Experiment Station, on property of L. B. Mohler, Killbuck, R.F.D. Location—at north edge of Mohler farm on top of ridge at head of Hardy Run, southwest Hardy Township, Holmes County, Ohio; approximately 0.2 mile north of Hardy-Killbuck township line, 0.85 mile east of Monroe-Hardy township line, 0.1 mile east of north-south road. Ground elevation approximately 1170 feet.

Core examined May 26 and 27, 1947 by G. W. White. Note: Core boxes below 90 feet in part broken and depths given do not exactly match core. As good a reconciliation as possible has been made. The lack of clay below Lower Kittanning coal is exceptional.

	Thickness		From Surface	
	Ft.	In.	Ft.	In.
Middle Kittanning coal horizon				
"Surface, with coal blossom" (drillers report) ...	8	0	8	0
Interval—29 ft. 3 in.				
Sandstone, reported, (similar to next unit below?)..	22	3	30	3
Sandstone, coarse, feldspathic, angular, with ferruginous streaks	2	7	32	10
Siderite, resin brown, fine granular; a few sand grains in basal part	0	2	33	0
Sandstone, coarse angular, feldspathic; a few carbon fragments; base unconformable	2	4	35	4
Siderite, brown, fine crystalline, brecciated, slightly calcareous, ("clay ironstone")	0	3	35	7
Shale, very light gray; becomes coarser and more silty downward	1	0	36	7
Breccia, composed of coarse sand grains, mud fragments to ¼ inch, and carbon fragments. One irregular siderite fragment, 1½ inches in diameter	0	8	37	3
Oak Hill? clay—3 ft. 10 in.				
Clay, gray, impure	1	1	38	4
Clay, (reported, core not present)	2	9	41	1
Hamden—8 ft. 7 in.				
Shale, gray, calcareous, marine fossils	0	5	41	6
Shale, black, carbonaceous, calcareous, very fossiliferous, some white shell material preserved	3	0	44	6
Shale, same as above, becoming less calcareous and less fossiliferous downward	3	2	47	8
Shale, black, carbonaceous, non-calcareous, contains microfossils	2	0	49	8
Lower Kittanning coal—6 ft. 8 in.				
Shale, black, carbonaceous, pyritiferous, with a few 1/64-inch coal streaks	0	2½	49	10½
Coal, fine-banded, about half black shale bands	0	1	49	11½
Coal, bright, banded; in upper 3 inches bands thin; below, bands of anthaxylon to ¼ inch or more. Core badly broken	1	11	51	10½
Coal, bright, banded	0	1½	52	0
Shale, pyritiferous	0	⅛	52	0⅛

	Thickness Ft.	In.	From Surface Ft.	In.
Coal, bright, banded	0	¾	52	0⅞
Parting, interbedded fine-grained pyrite and pyritiferous fusain streaks	0	¾	52	1⅝
Coal, bright, banded; core broken	0	8½	52	10⅛
Shale, black, carbonaceous	0	⅜	52	10½
Coal, very bright, bands to ½ inch	0	3	53	1½
Coal, bright, banded, occasional 1/32-inch pyrite bands, anthraxylon bands to ¼ inch	0	4	53	5½
Coal, same as above, no pyrite bands visible	1	8	55	1½
Shale, gray	0	¼	55	1¾
Coal, somewhat shaly	0	½	55	2¼
Shale, dark gray	0	¼	55	2½
Coal, banded; with shaly streaks and ⅛ inch pyrite band	0	1½	55	4
Coal, banded, bright, with few thin, shaly streaks	0	10	56	2
Shale, black, carbonaceous, with many black coaly streaks to ⅛ inch	0	2	56	4
Interval — 9 ft. 11 in.				
Sandstone, medium to coarse, with clay and carbon shreds	0	4	56	8
Sandstone, white, medium to coarse, with some coal fragments	0	8	57	4
Shale, gray, clayey, fine-grained, occasional 1/32- to ⅛-inch pyrite crystals and concretions increasing in amount upward	5	8	63	0
Clay, gray, plastic, slightly micaceous, plant fragments; only slightly gritty	0	8	63	8
Shale, light gray, fine-grained, non-calcareous, one small pelecypod	1	4	65	0
Shale, light gray, fine-grained, clayey	1	3	66	3
Putnam Hill calcareous shale — 4 ft. 8 in.				
Shale, light gray, slightly calcareous, slightly fossiliferous; becomes darker downward and grades into next unit	0	6	66	9
Shale, dark gray to black, calcareous, a few microfossils	1	4	68	1
Shale, light gray, fine-grained, bedding obscure, almost clay-like. Contains irregular nodules of light tan siderite, very fine-grained, to 2 inches	1	3½	69	4½
Shale, dark gray, fine-grained, calcareous	0	3	69	7½
Limestone breccia, soft, clayey, calcareous; made up of shell fragments and clay	0	½	69	8
Shale, light gray, becomes dark gray downward, fine-grained, calcareous	1	8	71	4
Putnam Hill limestone — 4 ft. 11 in.				
Limestone, dark gray blue, fine crystalline to very fine crystalline, sparingly fossiliferous	0	9	72	1
Limestone, shaly; and shale, calcareous	0	1	72	2

	Thickness Ft.	In.	From Surface Ft.	In.
Limestone, dark, fine crystalline, sparingly fossiliferous; some zones more fossiliferous than others	2	7	74	9
Limestone, dark, fossiliferous, hard; thin, irregular bedding	0	2	74	11
Limestone, dark, fine crystalline, sparingly fossiliferous, some zones more fossiliferous than others. Irregular contact with coaly shale below	1	4	76	3
Brookville coal — 3 ft. 9 in.				
Shale, coaly, irregular in thickness; with fusain layers	0	1	76	4
Coal, bright, banded; some 1/32-inch fusain and bone coal layers. Thin films of bright yellow pyrite along some joints. Core somewhat broken	1	9	78	1
Clay, very dark, carbonaceous	0	4	78	5
Clay, dark gray, with slickensides	0	10	79	3
Clay shale, very dark, carbonaceous	0	4	79	7
Coal, banded, alternating 1/8-inch bright anthraxylon layers and 1/8-inch attritus, some attrital layers bony	0	5	80	0
Brookville clay — 2 ft. 11 in.				
Clay, very sandy, micaceous, and carbonaceous; becoming less sandy downward	0	6	80	6
Clay, dark, somewhat sandy and micaceous; with many plant fragments	0	10	81	4
Sandstone, white, coarse, micaceous, clay bonded; with many coaly fragments; bedding confused and in part brecciated	1	7	82	11
Tionesta coal — 1 ft. 9 in.				
Coal, bony, with many bright anthraxylon shreds 1/64 to 3/16 inch; thin fusain bands pyritized; some bright yellow pyrite along joints in coal. Coal becomes less bony downward. Lower few inches only slightly bony	1	9	84	8
Interval — 44 ft. 4 in.				
Shale, gray, fine-grained, becoming slightly more silty in lower part	4	0	88	8
Shale, clayey, with some thin layers of very sandy clay	3	4	92	0
Clay, very dark, silty, slickensided, many plant fragments, some coal fragments; grades into next unit	2	10	94	10
Clay shale, gray	1	2	96	0
Missing	1	0	97	0
Clay shale, gray	8	6	105	6
Sandstone, fine-grained; interbedded with shale	8	6	114	0
Sandstone, medium to coarse, a few thin shale partings	8	6	122	6

	Thickness Ft.	In.	From Surface Ft.	In.
Sandstone, medium-grained, micaceous, cross-bedded; bedding planes covered with mica flakes. Thin carbonaceous beds	6	6	129	0
Bedford coal horizon? — 6 ft. 0 in.				
Sandstone, carbonaceous	1	2	130	2
Sandstone, cross-bedded, medium-grained, micaceous, interbedded with carbonaceous sandstone streaks to 2 inches	4	10	135	0
Interval — 25 ft. 6 in.				
Sandstone, white, medium-grained, micaceous, argillaceous, angular grains; a few carbon streaks near bottom. Beds ⅛ to ½ inch; on outcrop probably weathers to "sandy shale"	4	3	139	3
Shale, carbonaceous, micaceous, with irregular lenses of white sandstone	0	6	139	9
Sandstone, white, medium-grained, angular	0	5	140	2
Shale, carbonaceous; white sandstone; cross-bedded	1	3	141	5
Sandstone, white to gray, with ¼-inch to 1-inch sandy, micaceous shale streaks	6	4	147	9
Sandstone, white, medium-grained, argillaceous and micaceous. Irregular carbonaceous, micaceous shale streaks 1/32- to 1-inch make up almost ⅓ of section	6	6	154	3
Sandstone, white, coarser than above, becoming coarser downward, with fewer carbonaceous shale streaks. Bottom 2 ft. has no carbonaceous shale	6	3	160	6

56-295. W along road ⅜ mi. N of Killbuck Twp. and 1⅞ mi. E of Monroe Twp., Hardy Twp.

	Ft.	In.
Clay blossom, *Middle Kittanning*	1	0
Sandstone, irregular, shaly	9	0
Shale, clay-like, weathered; and covered	9	6
Coal smut; and covered, *Lower Kittanning*	1	6
Clay; and covered	10	0
Clay shale, with ore balls, weathers to greenish gray	34	0
Limestone, bluish gray, platy, hard, dense, fossiliferous, *Putnam Hill,* altitude 1,120 feet	6	2
Coal smut, clay; and covered, *Brookville*	8	0
Shale, sandy	25	0

57-124. N along Benton road at N corporation line of Millersburg, Hardy Twp.

	Ft.	In.
Sandstone, massive	12	0
Coal blossom, *Lower Kittanning*	0	5
Shale, and covered	26	0
Limestone, gray blue, *Putnam Hill,* altitude 1,140 feet	4	8
Clay shale	0	4

	Ft.	In.
Coal blossom, *Brookville*	0	6
Clay, siliceous	5	6
Sandstone, clay-bonded	10	6
Shale and covered.		

58-122. SE up road, NE¼SW¼ Sec. 20, ¼ mi. E of SE corner of Millersburg, Hardy Twp.

	Ft.	In.
Clay, and covered, *Lower Kittanning*	5	0
Clay shale, ferruginous	25	0
Limestone, *Putnam Hill*	4	0
Clay, coal, and covered	10	0
Sandstone, and covered	60	0
Covered, drift	40	0
Road forks, altitude 971 feet.		

59-9. NW along road from SE¼SE¼ to NE¼SW¼ Sec. 20, 1 mile SE of Millersburg, Hardy Twp.

		Ft.	In.
Shale and covered		26	0
Limestone, blue gray, dense, *Putnam Hill*		4	0
Clay and covered		12	0
Sandstone, shale; and covered		30	9
Coal smut, *Tionesta*		0	3
Clay and covered		5	0
Sandstone, shaly, micaceous		12	0
Shale, black, carbonaceous		1	0
Clay, sandy		2	0
Shale, gray, siliceous		6	0
Sandstone, shaly		20	6
Coal, shaly		0	9
Shale	*Bedford,*	0	8½
Coal	altitude	0	½
Shale, gray, soft	1,010 feet	1	9
Coal, bony		0	11
Clay and covered		10	0
Covered		22	2
Coal smut, *Lower Mercer*		0	2
Clay, white		2	0
Clay and covered		16	6
Sandstone, massive, Massillon		20	0

60-66. NE along state road, from SE¼ Sec. 14, Hardy Twp. to SW¼ partial Sec. 13, Berlin Twp.

	Ft.	In.
Coal, loose pieces, *Middle Kittanning.*		
Sandstone, a few iron balls in upper 1 foot	37	0
Shale, dark, hard, bony, *Lower Kittanning*	0	8
Sandstone, shale, and covered	25	4
Limestone, *Putnam Hill,* altitude 1,150 feet	3	0
Clay shale	0	2
Coal, weathered, *Brookville*	1	4
Clay, light to gray, plastic	7	6

	Ft.	In.
Sandstone, white, ganister	3	0
Sandstone, light	10	0

61-24. E up hill along road NW¼SE¼ Sec. 17, SE Hardy Twp.

Sandstone, somewhat massive	25	0
Coal blossom, *Lower Kittanning*	0	6
Clay and covered	5	0
Covered	20	6
Shale, clay-like, with iron ore concretions	10	0
Limestone, blue gray, massive, *Putnam Hill*, altitude 1,150 feet	5	1
Coal, weathered, *Brookville*	1	8
Clay, white	10	9
Coal, weathered, *Tionesta*	0	3
Clay, white	5	0
Sandstone, shaly	20	0

62-42. In small mine in SW¼SW¼ Sec. 24 and up lane to hilltop at E-W road in NE¼SW¼ Sec. 24, SE Hardy Twp.

Shale, weathered		2	0
Coal, weathered, *Middle Kittanning*, altitude 1,210 feet		1	6
Clay, gray		2	4
Shale, ferruginous, weathered		10	2
Sandstone, and covered		62	4
Shale, dark, carbonaceous		3	0
Coal, good	*Lower Kittanning*	1	10
Shale, dark, hard	*Lower Kittanning*	0	¼
Coal, good	*Lower Kittanning*	0	9
Clay, dark		0	2
Clay, light, plastic		3	0

63-41. In ravine and 50 feet inside local mine of Carson Jones S of road, SW¼NE¼SE¼ Sec. 24, SE Hardy Twp.

Sandstone, coarse.			
Shale, sandy, coaly		0	3
Clay shale, gray		2	9
Shale, dark, carbonaceous	*Lower Kittanning*	0	4
Clay shale, gray	*Lower Kittanning*	0	6
Coal, bony	*Lower Kittanning*	0	4
Shale, dark, carbonaceous	*Lower Kittanning*	0	4
Clay, light, plastic		3	0
Shale, and covered		33	0
Limestone, *Putnam Hill*, altitude 1,120 feet		3	0
Coal blossom, *Brookville*		0	6

STRATIGRAPHIC SECTIONS FROM BERLIN TOWNSHIP

65-225. E up road NE¼SW¼ Sec. 7, NE Berlin Twp.

Shale, sandy	6	0
Coal, weathered, *Middle Kittanning*	0	11

	Ft.	In.
Clay, impure	2	0
Sandstone, irregular and thin-bedded	38	11
Shale, ferruginous, and covered	12	0
Coal, weathered, *Lower Kittanning,* altitude 1,210 feet	2	6
Clay.		

66-91. S along road in SW¼SW¼ Sec. 6, N of Berlin, Berlin Twp.

	Ft.	In.
Sandstone, coarse	30	0
Covered	5	0
Clay shale, weathered	2	0
Coal, weathered, *Lower Kittanning*	2	1
Clay, plastic	4	0
Clay shale, and covered	28	0
Limestone, *Putnam Hill,* altitude 1,170 feet	3	0
Coal blossom, and covered, *Brookville*	2	0
Clay, light, plastic	5	8
Clay, very siliceous to sandy, with iron stains	2	0
Shale, siliceous	10	0

67-113. NE along Millersburg road, 1 mi. WSW of Berlin village, Berlin Twp.

		Ft.	In.
Clay shale, somewhat calcareous, with ore balls		15	0
Limestone, *Putnam Hill*		4	0
Coal, clay, and covered, *Brookville*		0	4
Clay, light, plastic, good		3	8
Clay, siliceous		3	0
Sandstone		3	0
Covered; and sandstone, shaly		32	0
Sandstone, shaly		22	0
Shale, black, hard, carbonaceous	*Bedford,*	0	7
Shale, dark gray, siliceous	altitude	1	0
Shale, black, hard, carbonaceous	1,120 feet	0	8
Shale, dark gray, siliceous		2	0
Clay shale		3	0

68-60. E in ravine crossing E boundary of Sec. 23, 200 yards north of a road, SW Berlin Twp.

	Ft.	In.
Sandstone and covered	42	4
Shale, sandy; and covered	14	0
Shale, siliceous, with iron stains	5	0
Shale, dark gray	1	0
Coal, shaly, *Bedford*	0	10
Clay, impure	2	0
Clay and covered	3	6
Shale, sandy	5	0
Covered	3	0
Shale, gray	0	6
Shale, black, hard, bone, *Upper Mercer* coal horizon	1	6
Shale, gray	0	6
Shale, sandy; and covered	15	6

		Ft.	In.
Limestone, ferruginous	*Lower Mercer,* altitude 1,060 feet	0	1
Limestone, very dark blue, shaly, almost carbonaceous, fossiliferous.		0	6
Limestone, lighter blue, fine-grained, very dense, massive		3	6
Limestone, dark, granular, fossiliferous		0	6
Clay shale		0	1
Coal, fair, *Middle Mercer*		0	3
Clay, iron-stained, siliceous; with plant fossils		4	0
Clay shale, gray		12	8
Shale, black, hard, carbonaceous, *Lower Mercer*		1	8
Shale, gray		20	0

69-22. In small stream and along road ½ mi. N of Mechanic Twp. and 1½ mi. E of Hardy Twp., SW Berlin Twp.

	Ft.	In.
Clay and covered	8	0
Limestone, (not entire thickness), *Lower Mercer*	1	0
Clay, coal; and covered, *Middle Mercer*	12	0
Sandstone, shaly	3	0
Shale, sandy	4	0
Shale, soft	0	7
Coal, *Lower Mercer,* altitude 1,065 feet	0	5
Shale, sandy	3	0

70-109. W up road from 200 yards N of NE¼ Sec. 2, Mechanic Twp. to hilltop at road fork on twp. line, S. Berlin Twp.

	Ft.	In.
Sandstone, massive	40	0
Road fork, altitude 1,217 feet.		
Sandstone, massive	29	0
Clay and covered, *Lower Kittanning*	12	0
Shale, ferruginous	10	0
Ore, nodular, weathered, *Vanport horizon?*	1	0
Clay shale, some iron balls	14	6
Limestone, gray, hard, *Putnam Hill*	3	6
Coal, weathered, *Brookville*	0	6
Clay	3	2
Shale, siliceous	42	2
Coal, shaly, *Bedford*	0	5
Clay, impure	1	0
Shale, siliceous	10	0
Covered, and shale	7	9

71-45. N up road to top of ridge 1 mi. SSW of Berlin, thence E up ridge to abandoned mine of D. J. Hitchcock, Berlin Twp. (The 6 upper measurements reported by Delbert Hitchcock.)

		Ft.	In.
Sandstone, brown to yellow		30	0
"Soapstone"		10	0
Coal, bony	*Lower Kittanning*	0	10
"Fire clay" (clay shale)		0	4
Coal, good		2	2
Covered, (probably all clay)		7	4

	Ft.	In.
Clay shale, with iron concretions	5	0
Covered	3	0
Limestone, *Putnam Hill*, altitude 1,170 feet	2	0
Coal, clay, and covered, *Brookville*	3	0
Covered	27	8
Sandstone, white	3	4
Sandstone, thin-bedded	5	8
Clay, sandstone, shale, and covered	23	0
Coal blossom, *Bedford*	1	0
Covered	27	0
Limestone, blue, hard, fossiliferous, *Lower Mercer*	3	0
Coal blossom, *Middle Mercer*	0	3
Clay, light, plastic	2	0

72-46. Along road from 1½ mi. SSW of Berlin to a point 1 mi. S of Berlin, Berlin Twp.

Sandstone, and covered	51	0
Coal, old mine, *Lower Kittanning*	3	0
Clay and covered	3	0
Covered	13	2
Clay shale, with iron concretions; weathered greenish yellow	8	0
Limestone, blue gray, hard, *Putnam Hill*	3	0
Coal, clay; and covered, *Brookville*	3	0
Shale and covered	29	6
Shale, sandy	15	0
Covered	18	0
Limestone, blue, hard, fossiliferous, *Lower Mercer*, altitude 1,060 feet	4	0
Shale, dark, carbonaceous, *Middle Mercer*	0	8
Clay and covered	2	0
Clay shale, gray to buff	6	4
Sandstone, white, clay-bonded, ganister	2	0
Shale, sandy; and covered	32	0
Sandstone, thin-bedded	2	0
Clay shale with ore nodules, *Boggs*	2	0
Shale, coaly } *Lower Mercer*	0	2
Coal } *Lower Mercer*	0	5
Shale, siliceous; with plant fossils	5	0
Shale, sandy	5	0

73-86. NE along road ¼ mi. N of Clark Twp. and 1¼ mi. W of Walnut Creek Twp., SE Berlin Twp.

Sandstone, coarse	20	0
Clay, and covered, *Lower Kittanning* horizon	2	0
Covered	5	0
Clay shale, with ore balls	11	4
Limestone, dark, hard, very ferruginous } *Putnam Hill*, altitude 1,155 feet	0	3
Limestone, blue gray } *Putnam Hill*, altitude 1,155 feet	1	0
Coal blossom, *Brookville*	0	5

	Ft.	In.
Clay, light, siliceous	2	0
Ganister	5	0
Shale, greenish to gray, clayey, ferruginous	15	0
Coal blossom, *Tionesta*	0	2
Clay, light, plastic	3	0
Shale	19	7
Covered	10	0
Coal smut, *Bedford*	0	3
Clay	2	0

74-85. S from road fork ⅞ mi. W of Walnut Creek Twp. and ½ mi. N of Clark Twp. to crossroad and thence W 100 yards to hilltop, Berlin Township.

	Ft.	In.
Shale, gray, with iron stains	8	0
Clay, impure; and covered, *Middle Kittanning* horizon	1	8
Shale, sandy, slightly ferruginous	9	8
Sandstone, coarse	36	0
Coal blossom, *Lower Kittanning*	0	4
Clay, gray to pinkish, plastic	5	0
Clay shale, with iron concretions	26	8
Limestone, loose blocks and some layers; and covered, *Putnam Hill,* altitude 1,150 feet	2	0
Coal blossom, *Brookville*	0	4
Clay, light, plastic	3	0
Clay, very sandy to ganister	4	0
Clay, and covered	2	0

STRATIGRAPHIC SECTIONS FROM WALNUT CREEK TOWNSHIP

75-197. N along road to small mine in Lower Kittanning coal, ¾ mi. E of NE Walnut Creek Twp., Holmes Co., ¼ mi. E of SE partial Sec. 3, Wayne Twp., Tuscarawas Co. (Putnam Hill-Lower Kittanning interval reduced due to slumping; mine entry has pronounced slope toward surface of hill).

		Ft.	In.
Coal, hard, bony		0	3
Coal, good		2	2
Pyrite, (absent in places)	*Lower Kittanning*	0	½
Coal, good		0	9½
Clay shale, gray		0	⅝
Coal, fair		0	1½
Clay, dark, carbonaceous, impure		0	6
Clay, gray, plastic, impure, siliceous		2	0
Clay shale, with ore balls; and covered		10	2
Limestone, and covered, *Putnam Hill,* altitude 1,130 feet		1	0
Clay shale, gray		0	2
Coal, shaly, *Brookville*		0	1½
Clay, gray, plastic		10	0
Clay, white; shaly sandstone; and covered		10	0
Shale, sandy		19	8
Coal blossom, *Tionesta*		0	4
Clay, and covered; (mainly covered)		5	0

	Ft.	In.
Shale, and covered	16	0
Coal blossom, shaly, *Bedford*	0	6
Clay, impure, sandy	3	0
Shale, sandy	21	0
Limestone, blue, hard, fossiliferous, dense, *Lower Mercer*	0	6
Coal, clay, and covered	2	0

76-200. SE along the road ½ mi. SE of Trail, N Walnut Creek Twp.

Sandstone, sandy shale; and covered	52	0
Coal, old mine, *Lower Kittanning*	4	0
Covered	11	0
Sandstone and covered	15	0
Sandstone, massive	20	0
Covered	30	0
Coal, weathered, *Bedford*	0	9
Clay, siliceous, not pure	3	0
Shale, sandy	3	1
Shale, black, hard, bone } *Upper Mercer*	0	9
Clay shale, dark gray } *Upper Mercer*	0	3
Shale, black, hard, bone } *Upper Mercer*	0	3
Clay, impure	2	2
Shale, siliceous and impure, grading downward to clay-like shale	7	9
Limestone, blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,065 feet	1	10
Clay and covered, *Middle Mercer*	7	0
Shale, sandy	40	0

77-203. Along road at road fork at church, ¼ mi. E of crossroad 1 mi. S of Trail, Walnut Creek Twp.

Shale, dark, carbonaceous, very fossiliferous, *Hamden*	3	0
Coal, weathered, *Lower Kittanning*	3	3
Clay, impure	3	0
Shale, siliceous	16	10
Clay shale with ore balls	32	0
Limestone, weathered, *Putnam Hill*, altitude 1,125 feet	2	0
Clay shale, gray	0	2½
Coal, shaly } *Brookville*	0	2
Clay shale, dark } *Brookville*	0	2½
Coal, fair } *Brookville*	1	2

78-215. Along the road just S of the crossroad 1 mile S of Trail, Walnut Creek Twp.

Clay shale, with ore balls	10	0
Limestone, loose blocks, *Putnam Hill*	1	0
Clay; coal; and covered, *Brookville*	2	0
Clay and covered	7	0
Shale, sandy	51	0
Shale, clay-like	1	0
Coal, fair, *Bedford*, altitude 1,050 feet	1	7
Clay, impure	2	0

	Ft.	In.
Shale, with irregular white sandstone lenses	12	5
Shale, dark, carbonaceous, *Upper Mercer*	1	0
Clay and covered	2	0

79-216. S from valley bottom along new road location 1½ mi. N of Walnut Creek village, Walnut Creek Twp.

	Ft.	In.
Clay shale, greenish gray; with small ore balls	25	0
Limestone, gray, loose blocks, *Putnam Hill*	2	0
Clay shale, gray	0	2
Coal, poor	0	1
Clay shale, dark gray *Brookville*	0	1½
Coal, weathered	0	2
Clay, light, plastic, siliceous	3	3
Sandstone, white, shaly	11	4
Shale, siliceous to sandy	59	4
Limestone, dark blue, very flinty, fossiliferous, *Upper Mercer*	2	0
Coal, weathered, *Bedford*	1	1
Clay, gray, plastic	2	1
Shale, siliceous, ferruginous	4	1
Shale, dark, hard, carbonaceous, *Upper Mercer*	0	6
Clay, gray, plastic	3	0
Shale, clayey, ferruginous	7	4
Limestone, gray blue, hard, dense, fossiliferous, *Lower Mercer*, altitude 1,020 feet	3	1
Coal blossom, *Middle Mercer*	0	2
Clay and covered	3	0

80-219. N along road from road fork 2¼ mi. W of Trail and ¼ mi. S of Paint Twp. line, NW Walnut Creek Twp.

	Ft.	In.
Shale, sandy	15	0
Limestone, dark blue, hard, fossiliferous; with much flint, *Upper Mercer*, altitude 1,085 feet	2	2
Coal and covered, *Bedford*	2	0
Clay, clay shale; and covered	5	10
Shale, black, hard, carbonaceous, *Upper Mercer*	3	2
Clay, and covered	5	0

81-224. S up ravine to road thence E to 1,281 crossroad NE partial Sec. 8, NW Walnut Creek Twp.

	Ft.	In.
Crossroad, altitude 1,281 feet.		
Shale, siliceous, to sandy	22	4
Coal, weathered, *Middle Kittanning*	1	3
Clay, gray, siliceous, plastic	1	8
Sandstone, thin-bedded and irregular	19	1
Covered	26	4
Coal, old mine, *Lower Kittanning*	3	0
Covered	15	10
Sandstone, shaly, and shale, sandy	30	0
Limestone, *Putnam Hill*,	1	6
Coal, *Brookville*	0	1

	Ft.	In.
Clay, siliceous	3	5
Shale, siliceous, with large (2-foot) iron concretions	6	0
Clay shale, carbonaceous } *Tionesta*	0	2
Clay shale, light } *Tionesta*	0	3
Clay shale, carbonaceous } *Tionesta*	0	4
Clay, siliceous, plastic	1	8
Sandstone, white, clay-bonded	3	1
Ore, sandy	0	6

82-97. N up road to small mine in Lower Kittanning coal, thence up road to hilltop ¼ mi. S of state road, N½ partial Sec. 18, E Walnut Creek Twp.

	Ft.	In.
Shale, siliceous	31	0
Coal blossom, *Middle Kittanning*	1	0
Clay, and covered	3	0
Shale, sandy	22	8
Sandstone	22	0
Shale, gray to yellow; some iron stains; siliceous	21	0
Shale, black, carbonaceous, siliceous; marine fossils, *Hamden*	2	0
Coal, *Lower Kittanning,* altitude 1,140 feet	3	1
Clay, plastic	2	6

83-99. W up road NE¼ partial Sec. 23, SW Walnut Creek Twp.

	Ft.	In.
Shale, siliceous to sandy	29	0
Limestone, *Putnam Hill*	1	0
Coal blossom, *Brookville*	1	6
Clay, light, plastic, siliceous	3	0
Shale, siliceous	22	0
Clay, coal, and covered, *Tionesta*	2	0
Shale, siliceous	28	4
Coal, clay, and covered, *Bedford*	2	8
Covered	5	0
Sandstone, white, thin-bedded to shaly	11	0
Shale, dark, carbonaceous, *Middle Mercer*	1	0
Shale, clay-like; and impure clay	2	0
Clay shale with small ore balls	6	6
Ore, gray to tan, slightly nodular, massive, dense	0	2
Shale, dark to brown, clayey to siliceous	4	0
Limestone, very dark, hard, almost flinty, fossiliferous, massive, *Lower Mercer*	3	0
Covered	4	4
Road forks, elevation 1,005 feet.		

84-137. W along road from valley bottom ¼ mi. N of Clark Twp. line and ⅝ mi. E of Berlin Twp. line, to Berlin Twp. line, SW Walnut Creek Twp.

	Ft.	In.
Coal blossom, *Middle Kittanning*	1	6
Clay and covered	3	2
Shale, sandstone; and covered	28	0
Shale, dark, ferruginous, fossiliferous, *Hamden*	6	0
Coal, weathered, *Lower Kittanning*	1	10
Clay and covered	6	2

		Ft.	In.
Clay shale with ore balls		29	0
Limestone, blue gray, fossiliferous, *Putnam Hill*		1	3
Clay		0	3
Coal, fair	*Brookville,* altitude 1,080 feet	0	5
Shale, dark, clay-like		0	3
Coal, fair		0	7
Clay, good		5	0
Shale, white, sandy; and covered		4	3
Shale, siliceous; increasingly sandy towards top		19	10
Shale, black, coaly	*Tionesta*	0	4
Coal, shaly		0	2
Clay, light, siliceous		4	0
Sandstone, thin-bedded to shaly		32	8
Flint, black; and covered, *Upper Mercer*		1	0
Coal blossom, *Bedford*		1	0
Clay and covered		3	0

85-119. E up township line road NW¼NE¼ Sec. 3, N Clark Twp. and S. partial Sec. 23, Walnut Creek Twp.

		Ft.	In.
Shale, siliceous		10	0
Coal, blossom, *Lower Kittanning*		1	6
Clay and covered		8	0
Shale, siliceous		28	0
Clay shale, with iron concretions		6	10
Limestone, loose pieces, *Putnam Hill*		1	0
Clay		0	2
Coal, poor	*Brookville*	0	6
Shale, dark, carbonaceous		0	2
Coal, fair		0	4
Clay, light, plastic		7	0
Sandstone, light, shaly, clay-bonded		3	0
Shale, siliceous		7	4
Clay shale, a few ore balls		5	8
Coal smut, *Tionesta*		0	4
Clay, light, plastic		2	8
Sandstone		5	0
Clay		4	0
Shale and covered		29	10
Limestone, dark, hard, much black flint, *Upper Mercer*		2	0
Clay		0	2
Coal, fair	*Bedford,* altitude 1,050 feet	0	8
Clay shale		0	2
Coal, fair		0	2
Shale, dark, carbonaceous		0	4
Coal, shaly		0	5
Clay, light gray to yellow, plastic, siliceous		3	0

86-120. S up road from valley of Goose Creek to road fork at state road in NW¼ Sec. 19, 1 mi. W of Walnut Creek village, Walnut Creek Twp.

	Ft.	In.
Shale, dark, calcareous, fossiliferous, *Hamden*	8	0
Coal, weathered, *Lower Kittanning*	2	2

		Ft.	In.
Clay, light, plastic		8	6
Clay shale, with iron balls in lower 14 feet		37	8
Limestone, gray, *Putnam Hill*, altitude 1,115 feet		1	0
Clay shale		0	3
Coal		0	3
Clay shale, dark	*Brookville*	0	2
Coal, fair		0	10
Clay, light, plastic		5	6
Sandstone, white, clay-bonded, micaceous		3	6
Sandstone, shaly		12	0
Sandstone, thin-bedded		10	2
Coal, shaly, *Tionesta*		0	3
Clay, light, plastic, siliceous		3	0
Sandstone, white, thin-bedded, clay-bonded		3	9
Sandstone, thin-bedded to shaly		22	0
Limestone, blue black, hard, flinty, *Upper Mercer*		2	9
Coal, bony	*Bedford*	0	11
Coal, cannel, fair to bony		0	10
Clay, light, plastic, fair		3	0
Shale, and covered		10	2
Limestone, dark blue, hard, granular to dense, fossiliferous, *Lower Mercer*		1	0
Clay shale		0	2
Coal smut, *Middle Mercer*		0	2
Clay shale		8	0

87-107. S up road from valley of Goose Creek to Walnut Creek village, NW¼ Sec. 20, Walnut Creek Twp.

		Ft.	In.
Sandstone		7	0
Clay shale, ferruginous; with ore balls		10	0
Shale, dark, somewhat carbonaceous; iron stained where exposed		5	6
Ore, nodular, dense, hard, calcareous, *Hamden*		0	6
Clay shale		1	0
Coal, weathered, *Lower Kittanning*		1	8
Clay, plastic		4	0
Covered		10	10
Clay shale, with ore balls decreasing in amount upward		36	0
Limestone, gray blue, harder than usual, *Putnam Hill*, altitude 1,105 feet		3	0
Clay shale		0	3
Coal		0	5
Clay shale	*Brookville*	0	2
Coal		0	5
Clay, siliceous		3	0
Sandstone, white to buff		19	3
Coal, shaly, *Tionesta*		0	3
Clay, siliceous		2	0
Sandstone, shaly		2	9
Sandstone, white		25	0
Limestone and flint, weathered, *Upper Mercer*		3	0
Coal, shaly, *Bedford*		1	8
Clay, micaceous and sandy		2	6

	Ft.	In.
Sandstone, white, micaceous, and clay-bonded	4	0
Clay shale, slightly ferruginous	9	0
Ore, shaly	0	5
Limestone, blue, hard, fossiliferous, *Lower Mercer*	3	0
Ore, calcareous	0	3
Coal, *Middle Mercer*	0	2
Clay	2	0
Shale, carbonaceous	2	0
Coal, shaly } *Flint Ridge*	0	2
Clay, with thin coaly streaks } *Flint Ridge*	0	5
Coal, bony } *Flint Ridge*	1	1
Clay, plastic	3	0
Shale, yellow to gray	12	6

88-106. From crossroad ⅝ mi. S of Walnut Creek village N along state road to school in village, Walnut Creek Twp.

	Ft.	In.
Sandstone	13	8
Shale, gray to dark, slightly carbonaceous and ferruginous, stained reddish brown	9	0
Shale, gray to dark, fissile	5	8
Shale and covered	6	4
Clay, and covered, *Lower Kittanning*	5	0
Shale, and covered	8	0
Shale, greenish yellow to gray brown, siliceous	36	6
Limestone, blue gray, hard; (not full thickness), *Putnam Hill*	0	6
Coal, fair } *Brookville*	0	5
Clay shale } *Brookville*	0	2
Coal, fair } *Brookville*	0	8
Clay, and covered	1	0
Clay and shale	10	5
Shale, sandy	14	0
Covered	6	0
Sandstone, white to yellow; somewhat ganister-like	25	0
Sandstone, thin-bedded to shaly	10	0
Limestone, very dark blue, hard, fossiliferous, flinty in part, *Upper Mercer*	2	0
Coal, shaly, *Bedford*	1	1
Clay, impure	3	0
Clay shale, iron-stained	4	11
Clay shale with ore balls	6	0
Limestone, dark blue, hard, fossiliferous, *Lower Mercer*	3	4
Coal, shaly, *Middle Mercer*	0	4
Clay, good	4	0
Covered	3	8
Clay shale, gray	4	0
Covered	7	0

Crossroad, altitude 996 feet.

89-132. W along road NW¼ Sec. 16, Walnut Creek Twp.

	Ft.	In.
Sandstone, thin-bedded	10	0
Shale, dark, ferruginous, *Hamden*	1	6

	Ft.	In.
Coal blossom, *Lower Kittanning*	0	6
Clay, light, siliceous, plastic	9	0
Shale, yellow brown, siliceous, a few iron concretions up to 8 inches	47	8
Shale, with many iron concretions 1 inch to 4 inches	7	4
Clay and covered, *Putnam Hill* horizon	2	0
Coal blossom, *Brookville,* altitude 1,107 feet	1	0
Clay, light, plastic	4	0
Sandstone, clay-bonded	6	0
Shale, sandy	18	3
Coal smut, *Tionesta*	0	1
Clay, plastic	1	6
Shale, sandy, (upper part sandstone, thin-bedded)	22	6
Limestone, dark, hard, very flinty, *Upper Mercer*	2	0
Coal, weathered, *Bedford*	2	1
Clay	1	0

90-133. NW along road in SW¼NE¼ Sec. 16, Walnut Creek Twp.

	Ft.	In.
Shale, sandy	20	0
Coal blossom	0	4
Clay, light, plastic	1	4
Clay shale, with small iron concretions	1	8
Limestone, very dark, hard, mostly black flint, *Upper Mercer*	2	1
Coal, shaly, weathered, *Bedford*	2	2
Clay, impure	1	0
Shale, mostly clayey, somewhat ferruginous	19	7
Limestone, dark blue, hard, fossiliferous, *Lower Mercer*	1	8
Coal, weathered, poor, *Middle Mercer*	0	11
Clay and clay shale	2	0
Shale, sandy	4	0

Valley floor, elevation 1,000 feet.

91-183. S along road from NE¼NW¼ Sec. 1, to hilltop at township line, 2 mi. S of Walnut Creek village, Walnut Creek Twp.

	Ft.	In.
Shale, siliceous; grading upward to sandy shale	34	0
Clay shale, ferruginous	5	0
Coal blossom, *Middle Kittanning*	1	0
Clay, clay shale, somewhat ferruginous; and covered	37	0
Limestone, dark, (almost black), loose blocks, hard, fossiliferous, and apparently (but not actually) somewhat flinty, *Hamden*	0	8
Clay, light, plastic, *Lower Kittanning*	4	0
Sandstone, white; with small black to dark red iron spots	0	9
Sandstone, light, thin-bedded	17	0
Shale, sandy	6	0
Shale, calcareous, with iron nodules; grading upward to siliceous shale	27	0
Limestone, loose blocks, *Putnam Hill,* altitude 1,090 feet	1	0
Coal, shaly	0	3
Clay shale, dark } *Brookville*	0	1
Coal, fair	1	9

	Ft.	In.
Clay, gray, plastic	4	0
Shale, sandy	12	0
Coal smut, *Tionesta*	0	1
Clay	5	0
Shale, siliceous, with large ore balls	20	0
Covered	3	4
Flint, black, loose pieces, *Upper Mercer*	0	6
Coal blossom, *Bedford*	0	6
Clay, light, plastic, siliceous	5	0
Covered	6	0

92-190. E along state road from NE¼ Sec. 1 to NW¼ Sec. 5, 2 mi. SE of Walnut Creek village, Walnut Creek Twp.

Shale, with small ore balls	5	0
Coal blossom, (same thickness reported from old mine nearby), *Middle Kittanning*	1	9
Clay, gray, siliceous, plastic	6	8
Shale, white, sandy, and covered	21	6
Coal, good, formerly mined, (reported), *Lower Kittanning*	2	4
Clay (reported)	3	0
Shale, clay, and covered	5	4
Shale, siliceous, slightly ferruginous	51	0
Limestone, loose blocks, *Putnam Hill,* altitude 1,080 feet	0	6
Coal blossom, *Brookville*	0	6
Clay, light, plastic	5	0
Sandstone, white, clay-bonded.		

93-134. E up road from NW¼SE¼ Sec. 25 to hilltop in NE¼SE¼ Sec. 25, SE Walnut Creek Twp. (Middle Kittanning coal measured in mine of C. C. Glick).

Sandstone, shaly	7	0
Shale, siliceous	39	0
Shale and covered	6	0
Shale, dark, fossiliferous, carbonaceous, *Washingtonville*	2	0
Shale, dark, moderately soft	0	11
Coal, good, *Middle Kittanning,* altitude 1,160 feet	2	10
Shale, gray, hard	1	0
Shale, and covered	13	1
Shale, with ore balls	10	0
Shale, dark, ferruginous, fossiliferous, calcareous; ore balls up to 8 inches present, *Hamden*	6	0
Coal, good, *Lower Kittanning* (two mines nearby)	2	9
Clay, good, plastic	5	4
Shale and covered	6	0
Shale, clay to siliceous; with ore balls	22	4
Covered, pieces of *Putnam Hill* limestone	2	0
Coal blossom, *Brookville*	1	3
Clay, light, plastic	6	0
Sandstone, clay-bonded	4	0
Sandstone, shaly	11	5
Clay, and covered, *Tionesta* horizon	1	0

	Ft.	In.
Shale, sandy	7	0
Shale, siliceous; a few ore balls	13	0
Clay shale, gray	1	0
Coal, shaly, *Bedford*	2	9
Clay	2	0
Clay shale with ore balls	10	9
Limestone, dark blue, hard, *Lower Mercer*	1	6
Coal, shaly, *Middle Mercer*	3	1
Clay, light, plastic	2	0

STRATIGRAPHIC SECTIONS FROM CLARK TOWNSHIP

95-172. E along a road SW¼SW¼ Sec. 2, central N Clark Twp.

Sandstone and covered	31	0
Clay and covered, *Lower Kittanning*	2	0
Clay shale, greenish, calcareous, with small nodules of ore; and covered	22	0
Coal, clay; and covered, *Brookville*	3	0
Sandstone, sandy shale; and covered	37	4
Coal smut, *Tionesta*	0	2
Clay and covered	2	0
Shale, sandy; and covered	18	6
Clay shale, greenish; with small iron concretions	2	0
Flint, black, hard, *Upper Mercer*, altitude 1,045 feet	2	0
Coal, shaly, *Bedford*	0	9
Clay, light, sandy	2	8
Shale, light, sandy	6	0

96-164. NW along road ¾ mi. SE of Farmerstown, NE¼SW¼ Sec. 11, Clark Twp.

Sandstone, thin-bedded to massive; deeply weathered		23	0
Shale, very sandy		10	0
Clay, impure		1	0
Shale, siliceous; and covered		11	4
Shale, slightly siliceous		38	8
Clay shale, with iron knots		17	0
Limestone, weathered pieces, *Putnam Hill*		1	0
Coal, weathered	*Brookville,*	0	2
Clay shale, dark	altitude	0	2½
Coal, weathered	1,040 feet	0	4
Clay, light, plastic, siliceous		4	6
Sandstone, light, thin-bedded		5	0

97-168. NE along road from SW¼NE¼ Sec. 12 to NE¼NE¼ Sec. 12, just SW of Farmerstown, Clark Twp.

Shale, sandy and ferruginous	5	0
Sandstone, yellow to buff, coarse; massive to thin-bedded	26	0
Conglomerate, fine-grained; quartz pebbles up to 5/16 inch, subangular; with discontinuous coal streaks up to 2½ inches, *Lower Kittanning* coal horizon	3	6

	Ft.	In.
Clay, impure — Lower Kittanning	1	5
Shale, sandy — Lower Kittanning	0	6
Clay, light, plastic, fair — Lower Kittanning	3	8
Clay shale, gray	2	2
Shale, siliceous, fine-grained; with occasional ovoid 1-foot concretions	40	7
Ore, carbonaceous and shaly	0	2
Clay, impure	1	8
Ore, shaly, fossiliferous	0	3
Limestone, gray blue, hard, dense, *Putnam Hill,* altitude 1,077 feet	1	3
Clay shale, gray	0	3
Coal, shaly — *Brookville*	0	2½
Clay shale, dark — *Brookville*	0	2
Coal, fair — *Brookville*	0	5
Clay, light, plastic, siliceous	6	9
Sandstone, light, thin-bedded	8	0

98-169. At five corners and N up road, ⅝ mi. WSW of Farmerstown, N Sec. 12, Clark Twp.

Shale, siliceous and ferruginous	10	0
Limestone, gray, hard, dense, fossiliferous, *Putnam Hill*	3	0
Coal blossom, *Brookville*	1	4
Clay, and covered	8	0
Shale, and covered	19	0
Covered	7	8
Five corners, elevation 1,041 feet.		
Clay, light to dark gray, plastic, *Tionesta*	10	0

99-170. NW along Charm-Farmerstown road from SE¼SW¼ to NW½SW¼ Sec. 8, 1½ mi. SE of Charm, Clark Twp.

Sandstone, iron-stained	5	0
Shale, sandy	10	0
Shale, and covered	3	0
Clay shale, dark	4	0
Shale, ferruginous, *Washingtonville*	0	10
Coal, fair, *Middle Kittanning,* altitude 1,190 feet	2	1
Clay, sandy and impure; many 1-inch to 3-inch layers of ore	11	4
Shale, very sandy; and sandstone, thin-bedded, ferruginous	21	4
Shale, siliceous, with thin, carbonaceous, and occasional coaly streaks, with plant fossils, *Lower Kittanning*	4	0
Clay, impure; and clay shale	4	0
Sandstone, cross-bedded; medium- to thin-bedded	12	0
Covered	6	0
Clay shale, ferruginous, (small ore knots)	15	0

100-117. E along road from SE¼SW¼ Sec. 4 to 1232 road fork in SE¼ Sec. 4, tnence N up hill, ½ to ¾ mi. E of Charm, NW Clark Twp.

Sandstone, thin-bedded to massive	17	0
Shale, sandy, with a little iron	20	5

	Ft.	In.
Coal, weathered, *Middle Kittanning*	1	6
Clay, sandy, impure	2	9
Sandstone, coarse, massive, increasingly thin-bedded upward	35	0
Sandstone, very coarse, pebbles of white quartz up to ¼ inch	6	0
Shale, siliceous	4	0
Shale, carbonaceous } *Lower Kittanning*	0	5
Coal } *Lower Kittanning*	0	1
Clay, gray, plastic, some iron stains	6	4
Clay shale, greenish-gray, only slightly ferruginous	19	10
Limestone, blue gray, hard, fossiliferous, *Putnam Hill*, altitude 1,130 feet	1	6
Coal, fair } *Brookville*	0	6
Clay shale, dark } *Brookville*	0	2½
Coal, fair } *Brookville*	0	3
Clay, white, plastic, siliceous	5	0
Sandstone, white, clay-bonded, with muscovite	2	8
Shale, siliceous	12	4
Coal, shaly, *Tionesta*	0	3
Clay, sandy	5	0
Sandstone, thin-bedded to shaly	25	0

101-118. Along road in SW¼NE¼ Sec. 4, NW Clark Twp.

Shale, carbonaceous and ferruginous	6	0
Coal (pieces) *Middle Kittanning?*	0	2
Clay, pink	3	0
Shale, siliceous	24	0
Shale, and covered	5	0
Shale, clayey; with ore balls	30	0
Limestone, poorly exposed, *Putnam Hill*, 1,135 feet	2	0
Clay	0	4
Coal, poor, weathered, *Brookville*	0	10
Clay, increasingly sandy toward the bottom	8	0
Shale, siliceous	5	0

102-62. In stream bank and up lane SE¼NW¼ Sec. 5, NW Clark Twp.

Limestone, blue, hard, fossiliferous, *Lower Mercer*	3	6
Clay shale	0	3
Coal, weathered, *Middle Mercer*	0	2
Clay	2	0
Clay and covered	2	0
Shale, sandy	21	7
Coal, shaly, *Lower Mercer*	0	8
Clay, gray	0	6
Sandstone, shaly; grading upward to shale, sandy, micaceous	21	6
Sandstone, cross-bedded, *Massillon*	5	0

Level of stream, altitude 990 feet.

103-88. W along road W of Charm in SE¼ Sec. 5 to NW¼NE¼ Sec. 6, Clark Twp.

Shale, with a few ore knots	15	0
Coal, weathered, *Middle Kittanning*	2	2

		Ft.	In.
Clay, plastic, with yellow iron stains		3	0
Shale		10	0
Sandstone and covered		9	4
Sandstone, coarse		20	0
Clay and covered, *Lower Kittanning*		5	0
Covered		51	8
Sandstone, 2-foot to 1-inch beds, yellow; mainly rather massive, *Homewood*		36	0
Clay shale, with iron concretions, (irregular)		0	3
Coal, fair		0	3
Clay, light, plastic		1	0
Limestone, dark blue, hard, fossiliferous	*Upper Mercer,*	0	5
Flint, black	altitude	0	11
Limestone, dark, flinty	1,067 feet	0	3
Coal, somewhat shaly, *Bedford*		2	0
Clay, siliceous		3	0
Shale, with a few ore balls, more at bottom		17	6
Covered and shale		3	0
Limestone, blue, fossiliferous, *Lower Mercer*		1	6
Clay and covered		2	0

104-90. In stream bed and along road NW¼NW¼ Sec. 7, NW Clark Twp.

Sandstone, shaly		3	0
Flint, black	*Upper Mercer,*	1	0
Limestone, dark blue, flinty	altitude 1,060 feet	0	8
Shale, clayey		0	8
Coal, bony, *Bedford*		1	6
Clay, gray, siliceous; with a few plant fossils		3	0
Clay, impure, to clay shale		3	8
Shale, black, hard, bone, *Upper Mercer*		1	2
Sandstone, light gray, clay-bonded; with plant fossils		1	0
Clay shale, greenish gray		0	8
Covered		1	0
Limestone, *Lower Mercer*		1	0
Coal, bony to canneloid, *Middle Mercer*		0	3
Clay shale		3	0

105-263. At the crossroad in SE¼NW¼ Sec. 15 cen. W Clark Twp.

Shale, siliceous		5	0
Shale, ferruginous		1	0
Coal, good	*Brookville,*	0	8
Clay shale, dark gray	altitude	0	3
Coal, shaly	1,085 feet	0	1½
Shale, ferruginous		1	0
Clay, siliceous to sandy		5	2
Sandstone, white, micaceous, thin-bedded		3	8
Coal smut, *Tionesta*		0	1
Clay and covered		3	6
Shale, siliceous		28	0
Flint, black, fossiliferous, *Upper Mercer*		1	2
Shale, carbonaceous to coaly, *Bedford*		1	0

106-262. Along road and in stream channel SW Sec. 15 W Clark Twp.

		Ft.	In.
Sandstone			
Flint, loose pieces, *Upper Mercer*			
Coal blossom, *Bedford*		0	6
Shale, and covered		23	9
Clay shale, with small ore balls		5	0
Ore, irregular, nodular, impure, weathered		0	5
Limestone, gray blue, thin-bedded, fossiliferous	*Lower Mercer,* altitude 1,010 feet	1	1
Limestone, gray blue, dense, fossiliferous		2	7
Limestone, gray blue, dense, fossiliferous, hard, massive, irregular fracture; with solution channels at base		0	8
Clay shale, carbonaceous		0	3
Coal, shaly, *Middle Mercer*		0	3
Clay, sandy, irregular; with plant fossils		2	0
Clay, shale; and covered		4	0
Coal, fair, *Flint Ridge*		0	4
Clay, light, plastic		1	0
Clay shale		4	0

107-261. In road bank at road fork SW¼SW¼NW¼ Sec. 16, Clark Twp.

		Ft.	In.
Sandstone.			
Clay shale, and covered		18	2
Coal, shaly, *Bedford*		0	5
Sandstone, white, hard, massive		0	7
Shale, sandy to siliceous, irregular, ferruginous		14	8
Ore, weathered		0	2
Limestone, very dark, thin-bedded	*Lower Mercer,* altitude 1,010 feet	0	4
Limestone, gray blue, dense, hard, fossiliferous		2	1
Coal, weathered, *Middle Mercer*		0	2
Clay, gray, plastic, siliceous		0	3
Clay, light, plastic, siliceous		3	2

108-185. E along road from SW¼NE¼ Sec. 16 to SW¼NW¼ Sec. 17, SW Clark Twp.

Shale, siliceous	5	0
Shale, weathered	1	0
Coal, blossom, *Middle Kittanning*	1	10
Clay, and covered	10	0
Shale, sandy; and covered	7	0
Sandstone, thin-bedded	25	0
Covered; a little clay, *Lower Kittanning* horizon?	14	8
Clay shale; grading upward to siliceous shale, ferruginous	43	2
Limestone, loose blocks, *Putnam Hill*	1	0
Clay shale, gray	0	2

		Ft.	In.
Coal, poor	*Brookville,* altitude, 1,100 feet	0	7
Clay shale, gray		0	2
Coal, fair		0	3½
Clay, gray, plastic, siliceous		4	0
Shale, light, sandy		7	0
Shale, yellow, sandy		11	8
Shale, siliceous; with ore balls		5	6
Shale, weathered, carbonaceous	*Bedford*	0	6
Coal, somewhat weathered, in part shaly		2	8
Clay, impure, very sandy		4	0
Covered		2	0
Shale, gray to dark, clayey		8	8
Coal, shaly	*Upper Mercer*	0	3
Clay, impure		1	1
Coal, shaly		1	0
Clay, dark, hard, ganister-like		1	8
Clay, ganister-like, hard		6	0
Sandstone, white, very hard, clay-bonded; with plant fossils		0	6
Shale, coaly, *Middle Mercer?*		0	2
Clay, white, hard, very sandy		5	8
Clay shale		6	0

109-186. E along road to hilltop in cen. Sec. 25, Clark Twp.
Hilltop.

	Ft.	In.
Shale, siliceous	12	0
Clay shale, somewhat ferruginous	20	3
Limestone, gray, loose blocks, *Putnam Hill,* altitude, 1,075 feet	0	6
Coal blossom, *Brookville*	1	3
Clay and covered	11	4
Shale, sandy	11	4
Covered	62	4
Limestone, blue, hard, dense, fossiliferous; not entire thickness, *Lower Mercer*	2	0
Covered	20	0
Sandstone, massive, *Massillon*	50	0

110-142. E and NE up road in Crawford Twp., Coshocton Co. to road fork at county line, SW corner Sec. 21, Clark Twp.

	Ft.	In.
Coal blossom, *Middle Kittanning*	0	6
Clay, and covered	3	0
Covered	8	0
Shale, siliceous to sandy	16	0
Shale, ferruginous	10	0
Covered	8	0
Clay, and covered, *Lower Kittanning* horizon	10	0
Shale, siliceous	35	0
Clay shale, greenish gray; with ore balls	10	0
Limestone, *Putnam Hill,* altitude 1,060 feet	2	0
Clay shale, gray	0	2

		Ft.	In.
Coal, weathered	*Brookville*	0	5
Clay shale, gray	*Brookville*	0	3
Coal, weathered	*Brookville*	0	4
Clay		6	0

111-154. SE along road cen. Sec. 21, SE Clark Twp.

		Ft.	In.
Shale, sandy		25	0
Coal blossom, *Middle Kittanning*		0	10
Clay, and covered		8	0
Shale, and covered		2	7
Shale, gray, somewhat ferruginous		14	0
Coal, shaly, weathered	*Lower Kittanning,* altitude 1,100 feet	0	4
Coal, weathered	*Lower Kittanning,* altitude 1,100 feet	1	6
Clay, light, plastic, a few yellow stains		9	2
Shale, siliceous		28	10
Covered		10	0

112-153. Up road SE of crossroad, SE¼SE¼ Sec. 21, at NW edge of Baltic, Clark Twp.

	Ft.	In.
Shale, clay-like, ferruginous; with ore balls	9	4
Coal, weathered, *Lower Kittanning*	2	2
Clay, light, siliceous to sandy	5	0
Clay, light, sandy	5	6
Shale, siliceous; increasingly sandy toward top	29	0
Shale, gray to yellow, clay-like, ferruginous; with occasional ore balls	15	0
Limestone, bluish gray, loose blocks, fossiliferous, *Putnam Hill,* altitude 1,050 feet	1	0
Coal blossom, *Brookville*	0	6

113-150. W along road NE¼SW¼SW¼ Sec. 17 SE Clark Twp.

		Ft.	In.
Clay shale, with ore nodules		4	0
Sandstone, and covered		17	0
Coal blossom, *Lower Kittanning*		0	4
Covered		32	8
Clay shale, and covered		5	0
Coal, poor	*Brookville*	0	4
Clay shale, dark	*Brookville*	0	3
Coal, poor	*Brookville*	0	4
Clay, light, plastic		4	1
Sandstone, white, thin-bedded, clay-bonded		6	0
Shale, siliceous		13	0
Covered		12	0

Creek level, altitude 1,025 feet.

114-149. W along road in SW¼SE¼ and SE¼SW¼ Sec. 17, ½ mi. SE of Sugar Creek, Clark Twp.

	Ft.	In.
Clay, light, plastic, *Lower Kittanning*	5	0
Sandstone, white; and covered	15	0

	Ft.	In.
Sandstone, shaly	12	0
Clay shale, and covered	5	1
Coal, (not full thickness) — *Brookville*, altitude 1,065 feet	0	2
Clay shale, dark — *Brookville*, altitude 1,065 feet	0	3
Coal — *Brookville*, altitude 1,065 feet	0	4
Clay, gray, plastic, good	5	2
Sandstone, white, clay-bonded	20	0

115-148. In ravine W of road SW¼NE¼ Sec. 24 SE Clark Twp.

	Ft.	In.
Shale, carbonaceous; increasingly siliceous toward top	20	0
Coal, bony — *Lower Kittanning*	0	6
Coal, mined — *Lower Kittanning*	2	6
Clay, and covered	5	0
Shale, and covered	40	4
Limestone, gray, hard, dense, platy, *Putnam Hill*, altitude 1,100 feet	5	8

116-147. SE and E along road, NE¼SW¼ Sec. 24, SE Clark Twp.

	Ft.	In.
Clay shale, gray, with ore balls up to 4 inches	8	0
Coal blossom, *Lower Kittanning*	1	6
Clay	4	0
Sandstone, shaly	10	0
Shale, clay-like to siliceous; and covered	31	6
Limestone, dark blue gray, hard, dense, *Putnam Hill*, altitude 1,080 feet	2	0
Shale, clay-like.		

117-152. In pit of General Clay Products Co., ½ mi. NE of Baltic, SE¼SE¼ Sec. 25, SE Clark Twp.

	Ft.	In.
Shale, clay-like to siliceous, (used in part)	51	0
Shale, dark, somewhat carbonaceous	2	6
Shale, black, hard, ferruginous, fossiliferous, *Washingtonville*	1	2
Coal, good, *Middle Kittanning*, altitude 1,130 feet	2	10
Clay, light, grayish to greenish, with pyrite	1	5
Clay, impure	1	9
Clay, dark gray	0	6
Clay, light, very sandy, almost a sandstone	5	8
Clay, impure, sandy, *Oak Hill?*	8	0
Covered	2	6
Coal, good, *Lower Kittanning*	1	10
Clay, clay-bonded sandstone, and covered	12	0
Shale, yellow, iron-stained in joints; occasionally with 6-inch nodules of ore	15	0
Shale (reported)	6	0

118-146. SE up road from school in SE edge of Baltic to top of 1,300 foot knob in NE¼SE¼ Sec. 5, Bucks Twp., Tuscarawas Co.

	Ft.	In.
Shale, sandy, with a few pieces of light gray, hard, dense, limestone	10	0
Shale, with ore balls	6	0

	Ft.	In.
Shale, sandy, and shaly sandstone; partially covered	115	0
Shale, siliceous to sandy	33	0
Clay shale, gray	14	0
Shale, gray to dark	8	0
Coal, weathered, *Middle Kittanning*	1	6½
Clay, and covered	3	0
Shale, gray to dark; somewhat siliceous and ferruginous	5	7
Shale, dark, carbonaceous	6	7
Shale, thin-bedded, sandy; carbonaceous layers up to 1-inch thick	1	4
Coal, fair, *Lower Kittanning,* altitude 1,100 feet	1	6
Clay, gray, siliceous, some iron stains; base concealed	6	0

119-167. Along state road and up an old road SE of 969-foot crossroad 1 mi. east of Halifax School, NE partial Sec. 11, Crawford Twp., Coshocton Co., 2½ mi. S of Holmes Co.

	Ft.	In.
Clay shale, ferruginous	10	0
Covered, and weathered clay, *Putnam Hill* horizon?	5	0
Clay shale, with carbonaceous streaks	0	3
Coal, shaly } *Brookville*	0	3
Clay shale, dark } *Brookville*	0	2
Coal, shaly } *Brookville*	0	5
Clay, light, plastic	6	3
Shale, sandy, light	8	0
Shale, and covered	6	11
Clay, sandy; and covered, *Tionesta*	2	0
Shale, siliceous to sandy	45	0
Flint, black, loose pieces, *Upper Mercer,* altitude 969 feet	1	0
Clay, coal smut; and covered, *Bedford*	2	8
Shale, and covered	20	0
Limestone, blue, hard, dense, somewhat granular, sparingly fossiliferous, *Lower Mercer*	6	0
Clay shale, with carbonaceous streaks	10	0

STRATIGRAPHIC SECTIONS FROM MECHANIC TOWNSHIP

121-83. S along road SE¼NE¼ Sec. 1, NE Mechanic Twp.

	Ft.	In.
Limestone, *Putnam Hill*	1	0
Coal } *Brookville*	0	2
Clay shale } *Brookville*	0	1
Coal } *Brookville*	0	10
Clay, plastic	7	2
Ganister	3	0
Shale, sandy, to sandstone	13	5
Shale, clayey	4	0
Coal, poor, *Tionesta*	0	8
Clay	3	6
Sandstone	28	8
Shale, sandy to clayey	5	8
Coal, shaly } *Bedford,* altitude 1,070 feet	0	3
Clay shale } *Bedford,* altitude 1,070 feet	1	3
Coal, bony } *Bedford,* altitude 1,070 feet	0	7

	Ft.	In.
Clay, impure and sandy	0	6
Sandstone, white, clay-bonded	2	0
Sandstone, sandy shale; and covered	18	1
Limestone, (not full measurement) *Lower Mercer*	2	0

122-78. W in ravine and up road, NE¼NE¼ Sec. 1 to NE¼NW¼ Sec. 1, NE Mechanic Twp.

		Ft.	In.
Sandstone, coarse		30	0
Coal; clay, and covered		4	0
Clay, plastic, siliceous, *Lower Kittanning*		5	0
Sandstone, clay-bonded, ganister		6	0
Shale, clayey, somewhat calcareous; with iron stains		10	0
Shale, gray green		2	0
Clay shale		3	0
Limestone, gray green, porous, ferruginous	*Vanport*	1	6
Shale, gray green, calcareous, grades into limestone	*Vanport*	3	0
Clay shale, with layers of ore nodules up to 8 inches		8	10
Ore, nodular; nodules massive and flat		0	6
Clay shale, gray green		11	1
Ore, gray blue, massive, dense, hard		0	5
Clay shale, with ore balls		3	0
Limestone, gray, *Putnam Hill*		1	0
Coal blossom, *Brookville*		0	4
Clay, plastic, good		8	0
Sandstone, ganister, shaly, poorly developed		1	0
Shale, with ore balls		32	11
Coal, weathered, shaly, *Bedford*		3	1
Clay, sandy, impure		0	6
Sandstone		3	10
Shale, sandy; and covered		6	0
Sandstone, white, ganister type		5	0
Shale, and covered		17	0
Shale, clayey, with occasional ore balls		22	0
Ore, shaly, weathered		0	2
Limestone, blue, hard, fossiliferous, massive	*Lower Mercer*	3	3
Limestone, dark blue, hard, shaly tendency on weathering	*Lower Mercer*	0	7
Coal, hard bone, *Middle Mercer*		0	3
Clay, gray, plastic		2	0
Clay shale		2	0
Shale, siliceous, (but not sandy)		12	0
Clay shale, gray		1	6
Shale, dark, carbonaceous	*Lower Mercer*	1	10
Clay, yellow	*Lower Mercer*	1	4
Clay, gray	*Lower Mercer*	0	6
Shale, dark, carbonaceous	*Lower Mercer*	3	6
Clay shale, gray to dark gray, lower 1 foot with occasional ½-inch coaly lenses		13	8

	Ft.	In.
Sandstone, thin-bedded	5	6
Sandstone, shaly, with carbonaceous streaks	1	6
Sandstone, massive, *Massillon*	40	0
Level of Doughty Creek, altitude 958 feet.		

123-82. In road ditch just east of Troyers Mill NE¼NE¼ Sec. 10, Mechanic Twp.

	Ft.	In.
Shale, coaly, *Bedford*	1	0
Clay, sandy, impure	1	0
Shale, clayey, bottom has some iron nodules	15	7
Ore, shaly, weathered	0	1
Limestone, blue, hard, fossiliferous, at old quarry, *Lower Mercer*	3	6
Shale, coaly, *Middle Mercer*	0	2
Clay, and covered	2	0
Shale, sandy, with a few 1-inch to 3-inch sandstone layers	10	4
Shale, gray, soft	2	8
Shale, somewhat carbonaceous, *Flint Ridge*	2	0
Clay shale, gray	3	0
Shale, gray to black, carbonaceous, clayey } *Lower Mercer*	5	7
Coal, shaly } *Lower Mercer*	0	1
Shale, gray, sandy	26	4
Sandstone, thin-bedded, and covered	15	0
Sandstone, massive, *Massillon*	20	0

124-81. NW up ravine to road and thence W and N, NE¼SW¼NE¼ Sec. 10 to SE¼NE¼NW¼ Sec. 10, NE Mechanic Twp.

	Ft.	In.
Limestone, loose blocks, *Putnam Hill*	0	6
Coal blossom, *Brookville*	0	6
Clay, plastic, siliceous	5	0
Sandstone, ganister-type	2	0
Shale, sandy; with iron knots	23	0
Sandstone, shaly	21	0
Sandstone, shaly; and covered	7	0
Coal smut, *Tionesta*	0	2
Clay, plastic	3	0
Sandstone, shaly; to sandy shale	8	10
Shale, coaly, *Bedford*	0	11
Clay, siliceous	0	6
Shale, sandy	10	7
Shale, with small ore nodules	7	0
Limestone, blue, hard, *Lower Mercer*	3	3
Shale, black, hard, bone, *Middle Mercer*	0	4
Clay, weathered	3	0
Sandstone, ¼-inch to 1-inch beds	16	6
Sandstone, massive to 3-inch beds	11	0
Shale	0	8
Sandstone	1	3
Shale	0	6
Sandstone	1	0

		Ft.	In.
Shale		0	6
Sandstone, massive		3	0
Shale		0	3
Sandstone, massive		2	0
Shale, gray, clay-like		0	10
Sandstone, somewhat massive	*Massillon*	25	0
Sandstone, cross-bedded, 2-inch to 6-inch beds	*Massillon*	6	0
Sandstone, massive	*Massillon*	45	0
Ore, nodular, sandy		1	0
Sandstone, massive		1	6
Ore, nodular, pure, with 1-inch to 4-inch sandy layers, and a few 1-inch to 2-inch coal lenses		0	6
Shale, black, bone	*Quakertown*	0	5
Coal, cannel, bony	*Quakertown*	0	5
Coal, bony	*Quakertown*	0	4
Clay shale, gray	*Quakertown*	0	2
Coal, shaly	*Quakertown*	0	6
Clay, impure		1	0

Level of Doughty Creek, altitude 930 feet.

125-110. N along road NW¼NE¼ Sec. 9 to road fork at N section line, NE Mechanic Twp.

	Ft.	In.
Limestone, *Putnam Hill*, altitude 1,140 feet	2	8
Clay shale	0	3
Coal, weathered, *Brookville*	1	9
Clay, light, plastic	5	6
Sandstone, clay-bonded	5	0
Sandstone, thin-bedded	22	6
Coal blossom, *Tionesta*	0	4
Sandstone, shaly	10	0
Shale, black, bone, *Bedford*	0	9
Shale, and covered	14	3
Limestone, blue, hard, fossiliferous, *Lower Mercer*	1	0

126-112. Along road ¼ mi. SE of Deetz School in NE¼SW¼ Sec. 2, NE Mechanic Twp.

	Ft.	In.
Clay shale, with iron stains	3	0
Limestone, gray blue, *Putnam Hill*	3	7
Clay	0	3
Coal, weathered, *Brookville*	2	3
Clay, light, plastic	5	0
Sandstone, white; and covered	7	0
Sandstone, shaly	29	0
Shale, carbonaceous	0	6
Shale, coaly, *Bedford*	1	2
Shale, gray, siliceous, micaceous, somewhat carbonaceous	2	6
Clay, impure	0	6
Sandstone, shaly	5	0
Covered	1	2

	Ft.	In.
Limestone, blue, hard, *Lower Mercer*, altitude 1,120 feet	2	6
Coal, fair, *Middle Mercer*	0	3
Clay, plastic	2	0

127-141. S up road between NW Sec. 2 and NE Sec. 3, ½ mile SE of Saltillo, NE Mechanic Twp.

Clay shale, ferruginous	3	0
Limestone, *Putnam Hill*, altitude 1,165 feet	3	1
Coal blossom, *Brookville*	1	0
Covered	9	0
Sandstone, white, shaly	2	6
Shale, sandy	27	0
Coal, shaly, *Tionesta*	0	2
Clay, siliceous	4	0
Shale, sandy	12	0
Shale, hard, carbonaceous, *Bedford*	1	6

128-40. SE and E in ravine and up road ½ mile to hilltop ½ mile S of SE corner of Hardy Twp., N Mechanic Twp.

Sandstone, yellow	20	0
Coal blossom, *Lower Kittanning*	0	6
Clay, light, plastic	4	0
Clay, and covered	10	0
Clay shale, with iron concretions	25	10
Limestone, blue gray, fossiliferous, *Putnam Hill*, altitude 1,125 feet	4	0
Clay shale	0	2
Coal, weathered, *Brookville*	1	9
Clay, light, plastic	2	0
Clay and covered	4	3
Sandstone, white, ganister-type	2	0
Shale, sandy; lower part iron-stained	22	0
Clay shale, grading upward to sandy shale; with ore balls which are fossiliferous, *Upper Mercer* horizon	6	0
Coal, shaly, *Bedford*	0	4
Clay, gray to dark	3	0
Shale, sandy	20	0
Shale, sandstone; and covered	83	2
Sandstone, massive	6	0
Coal, shaly, poorly exposed, *Vandusen?*	0	6
Clay and covered	2	0
Sandstone, coarse, massive, slightly cross-bedded (*Massillon*)	41	6
Sandstone, shaly to thin-bedded (*Massillon*)	6	0
Sandstone, massive, (cuts into coal in places) (*Massillon*)	1	6
Shale, dark, coaly, *Quakertown*	1	0
Shale, gray, sandy	1	0

129-39. From valley bottom E up road to road fork ¼ mile S of Webster Hall School, N central Mechanic Twp.

	Ft.	In.
Shale, sandy; grades upward to clay, or clay-bonded sandstone ..	15	0
Coal, weathered	1	0
Clay, siliceous, impure	2	6
Shale, siliceous	6	0
Shale, black, bone, hard, *Bedford*	0	9
Ganister, gray	0	2
Clay, dark	1	0
Clay, light	1	9
Shale, sandy	8	0
Covered, and sandy shale	13	10
Limestone, blue, hard, fossiliferous; weathers into beds 1-inch thick, *Lower Mercer*	3	0
Coal, shaly, *Middle Mercer*	0	3
Clay, plastic	1	0
Covered	12	4
Coal, shaly, *Flint Ridge,* altitude 1,008 feet	0	8
Clay, gray; with carbonaceous streaks	1	0

130-38. W along road 1⅝ mi. S of line between secs. 24 and 25 of Hardy Twp., N Mechanic Twp.

	Ft.	In.
Limestone, *Putnam Hill,* altitude 1,100 feet	3	0
Coal blossom, *Brookville*	1	3
Clay, white, plastic	2	0
Shale, sandy; and covered	42	1
Shale, and covered	51	0
Coal, shaly, *Lower Mercer*	0	8
Clay, gray, with dark streaks	1	0

131-37. Along road ½ mile E of NE¼ Sec. 10, ½ mile SSW of Grade, W Mechanic Twp.

	Ft.	In.
Shale, clayey, light	2	0
Shale, black, bone, *Bedford*	1	0
Clay, plastic	2	0
Covered	4	0
Shale, sandy	17	4
Limestone, blue, hard, *Lower Mercer,* altitude 1,015 feet	1	3
Shale, dark, soft	0	3
Coal, *Middle Mercer*	0	5
Shale, light, clayey	0	6
Shale, dark, carbonaceous	0	3
Clay, dark	2	0
Clay, light	2	0

132-125. E up road from Bucks Run, 2¼ mi. N of Coshocton Co. and 2¼ mi. E of Killbuck Twp., Mechanic Twp.

	Ft.	In.
Limestone, black, hard, flinty, *Upper Mercer*	1	6
Coal, clay; and covered, *Bedford*	3	0
Limestone, blue, hard; not full thickness, *Lower Mercer*	1	6

	Ft.	In.
Sandstone, shaly; and covered	19	10
Coal, clay; and covered, *Middle Mercer*	3	2
Sandstone, shale; and covered	55	0
Clay, weathered, *Vandusen* horizon?	1	0
Shale and sandy shale	21	0
Sandstone, coarse, massive, *Massillon*	36	0
Stream level of Bucks Run, altitude 895 feet.		

133-36. S up old Coshocton road from NW¼NE¼ Sec. 1 to SW¼NE¼ Sec. 1, NW Mechanic Twp.

	Ft.	In.
Sandstone, shaly to massive	10	0
Sandstone, very shaly, with coaly bands (*Lower Kittanning*)	0	6
Sandstone, shaly (*Lower Kittanning*)	0	6
Sandstone, very shaly, with coaly bands (*Lower Kittanning*)	0	7
Sandstone, shaly	10	0
Sandstone, and covered	30	4
Sandstone, shaly	5	0
Clay, light, plastic	2	8
Clay shale, with many iron concretions, some 6 inches in diameter	8	0
Clay shale, with a few iron concretions	9	2
Limestone, gray blue, massive, in 3-inch to 6-inch beds, *Putnam Hill*	3	1
Clay shale, gray	0	2
Coal, *Brookville*	0	11
Clay, light, plastic, good	10	5
Coal, very shaly, *Tionesta*	0	3
Clay, sandy	1	0
Sandstone, white, clay-bonded	9	6
Sandstone, shaly	29	6
Coal smut	0	2
Clay, sandy	0	6
Shale, sandy	2	6
Coal, shaly, to carbonaceous shale, *Bedford*	3	6
Clay, impure	2	0

134-34. Up road from road fork NE and E to hilltop, NE¼SW¼ to central E Sec. 2, NW Mechanic Twp.

	Ft.	In.
Sandstone	10	0
Coal blossom, *Lower Kittanning*	1	6
Clay	2	6
Shale, and covered	21	4
Shale, clay-like, with iron concretions	15	0
Limestone, blue to brown, thin-bedded, hard, *Putnam Hill,* altitude 1,075 feet	4	0
Coal, weathered, *Brookville*	1	8
Clay, white	5	0
Shale, sandy	23	4
Shale, and covered	6	0
Clay, gray, *Tionesta*	2	0
Shale, gray	3	0

	Ft.	In.
Shale, and covered	19	8
Shale, sandy	10	0
Clay, *Bedford*	1	0
Shale, sandy, and covered	45	2
Coal, shaly, scattered pieces, *Lower Mercer?*	0	6
Clay, and covered	5	0
Covered	18	1
Shale, sandy	4	0
Sandstone, and covered	10	0
Sandstone, shaly, with black stains (iron?) and carbonaceous matter	3	0
Shale, dark, carbonaceous, *Bear Run* horizon?	0	3
Sandstone, and covered	5	0
Sandstone, massive, *Massillon*	25	0
Clay, gray, siliceous, *Quakertown*	2	0
Sandstone, clay, and covered	8	0
Sandstone, and covered	25	0
Drift (outwash), covered	29	0
Mississippian system		
Sandstone, thin-bedded, *Waverly*	11	0
Road fork.		

135-4. NW and N up road NW¼SW¼ Sec. 12, W. Mechanic Twp.

	Ft.	In.
Sandstone, shaly	10	0
Coal, old mine, *Lower Kittanning*	4	0
Shale, and covered	40	11
Limestone, surface blocks, *Putnam Hill,* altitude 1,090 feet	1	0
Covered	1	0
Coal, shaly, weathered, *Brookville*	1	2
Clay, and covered	3	0
Covered	8	1
Coal smut, *Tionesta*	0	2
Clay, gray, soft, plastic	6	8
Coal blossom, *Bedford?*	1	0
Sandstone, shaly	16	0
Coal smut	0	2
Clay, dark, carbonaceous	1	0
Sandstone, thin-bedded	5	7
Covered	10	2
Coal blossom	0	4
Sandstone, ganister-type	2	0
Sandstone, soft	20	2

136-5. In valley of small stream and in road ditch, SW¼SE¼ Sec. 12, W Mechanic Twp.

	Ft.	In.
Limestone, blue, hard, fossiliferous; not full thickness, *Lower Mercer,* altitude 1,010 feet	1	6
Shale, dark, carbonaceous, *Middle Mercer* coal horizon	3	11
Shale	8	5
Shale, coaly, *Flint Ridge*	0	1

	Ft.	In.
Clay, and covered	3	6
Sandstone, massive, *Massillon*	44	0

137-68. N along road, NW¼ Sec. 19, SW Mechanic Twp.

	Ft.	In.
Shale, with some iron concretions	27	0
Coal, and clay, (poorly exposed), *Lower Kittanning*	1	0
Shale, sandy; to sandstone	50	0
Clay, gray, (weathered limestone), *Putnam Hill*	2	4
Shale, coaly } *Brookville*	0	4
Clay shale, dark, carbonaceous } altitude 1,089 feet	0	4
Clay, and covered	1	0
Covered	5	0
Sandstone, thin-bedded to shaly	20	0
Covered	11	0
Coal, clay; and covered, *Bedford*	3	0

138-259. Measured along road from N to S. S of Military Run, N central Sec. 13, Mechanic Twp.

	Ft.	In.
Pennsylvanian system		
Limestone, blue, loose pieces, *Lower Mercer.*		
Shale, sandy; and covered	22	0
Shale, coaly, blossom, *Lower Mercer*	0	4
Clay shale, increasingly ferruginous toward base	4	6
Clay shale, with ore balls, a few reaching 6 inches in diameter	6	0
Ore, light gray, dense, nodular, *Poverty Run*	0	11
Coal, fair, *Vandusen*	0	2
Clay, light, plastic, good	3	1
Ore, weathered	0	3
Clay, light, plastic	1	4
Ore, weathered	0	3
Clay, and covered, *Bear Run* horizon	3	0
Covered	5	11
Sandstone, shaly, clay-bonded	5	0
Shale, sandy	10	0
Sandstone, and covered	21	7
Mississippian system		
Covered	5	0
Sandstone, fine-grained, thin-bedded; in part concealed, *Vinton*	53	9
Road fork, elevation 904 feet.		

139-264. Along abandoned road SE¼NE¼ Sec. 22, SE Mechanic Twp.

	Ft.	In.
Sandstone, thin-bedded	0	6
Ore, nodular	0	2
Coal, shaly	0	1
Shale, sandy; and covered	6	8
Coal blossom, *Bedford*	1	0
Clay and covered	2	0
Shale, ferruginous; and covered	10	9
Ore and covered	1	0

	Ft.	In.
Limestone, gray blue, hard, dense, sparingly fossiliferous, *Lower Mercer,* altitude 1,043 feet	2	8
Ore, shaly to nodular, sandy, weathered	0	5
Coal, shaly, *Middle Mercer*	0	¾
Clay, light, siliceous, plastic	7	10
Sandstone, massive to thin-bedded	23	1

STRATIGRAPHIC SECTIONS FROM KILLBUCK TOWNSHIP

140-294. Up road from NE¼SW¼SW¼ Sec. 4 to NE¼SW¼ Sec. 4, NE Killbuck Twp.

Sandstone, micaceous, shaly	40	0
Covered	11	4
Limestone, gray blue to blue, hard, dense, fossiliferous, *Lower Mercer*	2	0
Covered	26	4
Sandstone, massive, *Massillon*	34	0
Covered	12	8
Ore, dark, dense, rather massive	0	6
Shale, dark gray, clay-like	1	4
Shale, gray	4	6
Covered	2	6
Coal, canneloid, somewhat bony, (not full thickness), *Quakertown,* altitude 950 feet	1	6
Covered	9	4
Clay to clay shale, light gray	1	8
Clay shale, dark, carbonaceous	1	6
Ore, nodular, impure	0	7
Clay shale	1	0

141-288. NE along road from NE¼SW¼ Sec. 5 to road turn N of road fork in SW¼NE¼NE¼ Sec. 5, central N Killbuck Twp.

Sandstone, massive, coarse	31	8
Shale, ferruginous, *Hamden*	1	0
Coal blossom, *Lower Kittanning*	2	4
Clay shale; and covered	17	8
Sandstone, thin-bedded	6	6
Shale, and covered	10	0
Limestone, loose pieces, *Putnam Hill,* altitude 1,140 feet	0	6
Clay, and covered, *Brookville*	12	5
Coal, shaly, *Tionesta*	0	3
Clay, light, siliceous, plastic	7	8
Shale, sandy	25	2
Coal, shaly, weathered, *Bedford*	1	6
Sandstone, white, micaceous, thin-bedded	3	0
Sandstone, massive; grading upward to shaly sandstone	22	4
Sandstone, shale; and covered	90	0
Ore, sandy; conglomerate; and sandstone, coarse, *Harrison*	1	0

Mississippian system

Sandstone, thin-bedded to shaly, *Waverly.*

142-285. NE and N up road from SW¼NE¼ Sec. 1, Killbuck Twp. to top of ridge in SE Monroe Twp. ¼ mi. N of twp. line.

	Ft.	In.
Pennsylvanian system		
Clay, weathered, *Lower Kittanning*	4	0
Shale, siliceous to sandy	32	0
Coal blossom	0	6
Shale, siliceous	11	4
Clay shale	10	0
Limestone, gray, hard, platy, fossiliferous, *Putnam Hill*, altitude 1,140 feet	5	1
Clay shale	0	5
Coal, shaly, weathered, *Brookville*	1	8
Clay	3	0
Shale	15	6
Coal, *Tionesta*	3	6
Covered	14	10
Sandstone, yellow, 2- to 3-inch beds	11	6
Sandstone, white; with carbonaceous streaks	0	4
Sandstone, yellow brown, massive, coarse	3	4
Coal, very shaly, *Bedford*	0	4
Clay, very impure, sandy, and micaceous	0	8
Shale, siliceous to sandy	11	3
Shale, carbonaceous; with plant fossils, *Upper Mercer?*	0	7
Clay, sandy, impure	1	2
Shale, sandy, and covered	14	10
Sandstone, shaly; and shale, sandy, with carbonaceous streaks	5	0
Shale, sandy, carbonaceous } *Flint Ridge?*	0	3
Sandstone, white } *Flint Ridge?*	0	2
Shale, black, carbonaceous } *Flint Ridge?*	0	1½
Clay shale, gray	1	0
Clay and covered	6	0
Shale, clay, slightly ferruginous	13	5
Shale, siliceous; grading upward into clay shale	7	0
Shale, sandy; with occasional ore balls	12	8
Coal, (not full thickness), *Quakertown*	0	4
Clay, gray, sandy	0	8
Sandstone, white, clay-bonded, plant fossils and charcoal pieces	1	0
Clay, light, plastic	4	10
Ore, irregular, sandy	0	7
Clay shale	1	10
Ore, nodular, impure	0	2
Clay shale, gray	0	6
Ore, nodular, weathered	1	4
Shale, gray	2	10
Ore, nodular, weathered	0	5
Clay shale, gray	5	10
Ore and covered, *Harrison*	2	0
Mississippian system		
Sandstone, thin-bedded to shaly, *Waverly*	90	0

143-299. SW and W along road from valley of Black Creek to hilltop in SE¼SW¼ Sec. 8, NW Killbuck Twp.

	Ft.	In.
Pennsylvanian system		
Hilltop.		
Shale, ferruginous	3	0
Limestone, blue, dense, fossiliferous, loose blocks, *Lower Mercer,* altitude 1,160 feet	1	0
Clay, coal, and covered, *Middle Mercer*	4	0
Covered	5	0
Clay and covered	4	0
Covered	20	0
Sandstone and covered (lower Pottsville)	78	0
Covered and sandstone	20	0
Mississippian system		
Sandstone, thin-bedded, *Vinton*	195	0

144-345A. S up ravine from NW¼SE¼ Sec. 23 to abandoned quarry S of road in SW¼SE¼ Sec. 23, SW Killbuck Twp.

	Ft.	In.
Shale, tan, weathered, with ore knots	11	0
Limestone, ferruginous } *Putnam Hill,* altitude 1,200 feet	0	2
Limestone, gray, fine-grained, fossiliferous, (not full thickness) } *Putnam Hill,* altitude 1,200 feet	5	0
Coal, clay, and covered, *Brookville*	4	0
Covered	11	5
Sandstone, thin-bedded	17	0
Ore, tan, calcareous, regular	0	5
Sandstone, shaly	3	6
Shale, siliceous	1	8
Shale, dark, ferruginous	1	4
Coal, somewhat bony, *Tionesta?*	0	6
Shale, gray	0	5
Shale, black, carbonaceous, sandy	0	4
Shale, dark, clayey, irregular	0	5
Limestone, very dark blue, granular, fossiliferous, very hard, (black flint in fields nearby), *Upper Mercer*	0	8
Coal, fair } *Bedford*	0	6
Coal, shaly, with shale streaks } *Bedford*	0	8
Coal, bright, with bony streaks } *Bedford*	0	7
Clay, dark gray, impure	2	0
Shale, fine-grained to sandy	1	5
Sandstone, coarse, thin-bedded	1	6
Shale, fine-grained	0	9
Coal, very shaly, with thin bright coal streaks, *Upper Mercer*	0	9
Clay, sandy, impure	1	4
Clay, very sandy	1	4
Shale, silty, becoming sandy upward	9	8
Covered, (shale?)	1	6
Limestone, light gray blue, finely crystalline, fossiliferous, hard, *Lower Mercer*	2	3
Clay, coal, and covered, *Middle Mercer*	2	1
Clay, sandy	3	0
Sandstone, white, clayey	3	0
Sandstone, coarse, massive, poorly exposed	30+	0

145-368. S along a road, NW¼NE¼ Sec. 22, Killbuck Twp.

	Ft.	In.
Clay shale, with many ore balls	3	0
Limestone, gray, hard, dense, fossiliferous, platy, *Putnam Hill*, altitude 1,190 feet	1	8
Clay, light, siliceous, plastic, partially micaceous; partly covered	11	8
Sandstone, white, shaly, clay-bonded	11	4
Sandstone, thin-bedded, medium-grained	34	0
Clay, coal smut; and covered, *Bedford*	2	0
Sandstone, shaly	12	4
Coal, shaly } *Upper Mercer*	0	3
Clay shale, dark gray } *Upper Mercer*	0	4
Coal, very shaly } *Upper Mercer*	0	5
Clay, impure	0	8
Sandstone, white, shaly, clay-bonded	6	0
Shale	5	0

146-346. W along road from SE¼SW¼ Sec. 21 to hilltop in SE¼SE¼ Sec. 22, SW Killbuck Twp.

	Ft.	In.
Pottsville formation		
Shale, sandy	10	0
Coal, shaly, weathered, *Bedford*	0	9
Sandstone, white, hard, clay-bonded; with plant fossils	2	6
Shale, sandy; and covered	13	9
Limestone, blue, hard, dense to slightly granular, fossiliferous, *Lower Mercer*	1	0
Clay, and covered	2	0
Shale	7	0
Clay, and covered, *Flint Ridge*	2	0
Shale, siliceous to sandy	16	0
Clay shale, carbonaceous, *Lower Mercer*	0	4
Clay, clay shale, and covered	16	8
Shale, sandy to siliceous	13	6
Shale, hard, carbonaceous, somewhat fissile, *Bear Run?*	1	3
Shale, reddish brown, fissile, somewhat ferruginous and carbonaceous	3	3
Shale, sandy, with a few sandstone layers	22	8
Sandstone, white, hard, medium-grained	2	0
Sandstone, buff, medium-grained	1	4
Conglomerate, ¼- to 1¼-inch quartz pebbles and 4- to 6-inch silicified, fossiliferous limestone cobbles in matrix of white, fine-grained sandstone, *Harrison*, altitude 1,000 feet	2	8
Mississippian system		
Logan formation		
Clay, ferruginous, sandy; (weathered Waverly beds)	3	0
Sandstone, light to buff olive, thin-bedded	25	0

147-273, 30. E along road from SW¼NE¼ Sec. 15 to hilltop in Sec. 14, 1 mi. ESE of Killbuck village, Killbuck Twp. (Bedford coal measured in mine of H. E. Leavengood in field S of road and projected into section).

		Ft.	In.
Pennsylvanian system			
Allegheny formation			
Hilltop.			
Coal, weathered, *Lower Kittanning*		1	8
Clay, dark		0	4
Clay, plastic		1	10
Clay, sandy, impure		1	0
Covered		31	8
Limestone, gray, dense, fossiliferous, *Putnam Hill*, altitude 1,120 feet		3	0
Covered		2	0
Pottsville formation			
Clay, plastic, siliceous		5	0
Covered		6	0
Shale, siliceous		16	0
Shale, gray		2	0
Shale, coaly	*Bedford*	0	5
Coal, fair	*Bedford*	0	7
Shale, dark	*Bedford*	0	4
Coal, fair to good	*Bedford*	2	8
Covered		10	2
Clay shale		3	0
Coal blossom, *Flint Ridge*, altitude 1,075 feet		0	2
Clay, sandy		1	0
Shale, siliceous, micaceous		3	10
Shale, coaly	*Lower Mercer*	0	3
Clay shale, gray	*Lower Mercer*	0	2
Shale, coaly	*Lower Mercer*	0	5
Sandstone, light, irregular, hard	*Lower Mercer*	0	8
Shale, black, siliceous, carbonaceous	*Lower Mercer*	0	10
Clay, very impure, sandy		1	0
Covered		12	6
Shale, siliceous, grading upward to sandy		12	8
Shale, gray, carbonaceous, *Vandusen* horizon		0	8
Shale and covered		7	8
Sandstone, white, thin-bedded	*Massillon*	3	0
Sandstone, massive	*Massillon*	25	0
Covered		2	0
Clay, weathered		5	6
Coal blossom, *Quakertown*		0	5
Clay, light, siliceous, plastic		5	5
Clay, impure, ferruginous		3	7
Sandstone, white, coarse		0	10
Conglomerate, ¼-inch white quartz pebbles	*Harrison*	0	7
Ore, nodular, sandy, weathered	*Harrison*	0	6
Mississippian system			
Logan formation, *Vinton* member			
Sandstone, gray, fine-grained, argillaceous		15	0
Sandstone, fine-grained, thin-bedded		50	0

148-31. S and SE up ravine from NE¼SE¼SW¼ Sec. 8 to NE¼ Sec. 13, NE Killbuck Twp.

		Ft.	In.
Pennsylvanian system			
Shale, gray		4	0
Shale, gray to dark, sandy		4	6
Shale, gray, with dark streaks		1	0
Shale, coaly	*Lower Kittanning*	0	10
Coal, good	*Lower Kittanning*	1	5
Coal, cannel	*Lower Kittanning*	0	8
Coal, good	*Lower Kittanning*	1	8
Clay, light, plastic		3	0
Shale, sandstone, and covered		55	3
Shale, gray, siliceous		15	0
Sandstone, shaly		6	0
Shale, siliceous to sandy		8	8
Sandstone, shaly		2	6
Shale, sandy		1	0
Ore, red to dark brown, calcareous, with fragments of fossils, fine- to coarse-grained, thickness variable, *Lower Mercer*		0	2
Limestone, dark blue, thin-bedded to shaly, granular, fossil fragments	*Lower Mercer,* altitude 1,020 feet	0	8
Limestone, dark blue, dense, very hard, fossiliferous; single bed with solution channels on bottom, some 8-inch deep, which cross, making projections	*Lower Mercer,* altitude 1,020 feet	1	9
Limestone, somewhat argillaceous	*Lower Mercer,* altitude 1,020 feet	0	8
Limestone, thin-bedded to shaly	*Lower Mercer,* altitude 1,020 feet	0	2
Coal, shaly, *Middle Mercer*		0	2
Clay, impure		0	3
Shale, sandy		4	2
Shale, gray		17	0
Clay shale, dark, *Lower Mercer*		0	2
Shale, gray, siliceous		0	6
Sandstone, irregularly bedded to massive		16	6
Shale, gray		1	0
Shale, carbonaceous, sandy, *Vandusen* coal horizon?		0	6
Sandstone, 1-inch to 3-inch beds	*Massillon*	10	8
Sandstone, massive	*Massillon*	34	0
Sandstone, 1-inch to 12-inch beds, coarse	*Massillon*	10	0
Ore, gray blue, with red weathered shells, coarse, sandy; with 1-inch to 5-inch flat nodules, calcareous; irregular in thickness and elevation, *Harrison*		1	2
Mississippian system			
Shale, sandy	*Vinton*	2	0
Sandstone, fine-grained, massive	*Vinton*	3	0

149-32. In Quillen mine entry and N up road to road fork, NE¼NW¼ Sec. 13, NE Killbuck Twp.

		Ft.	In.
Road fork, elevation 1,167 feet.			
Coal blossom, *Middle Kittanning*		0	6
Sandstone		11	4
Shale, sandy		19	8
Shale, dark		2	0
Shale, black, hard		1	0
Coal, cannel	*Lower Kittanning*	0	6
Coal, bituminous, good	*Lower Kittanning*	2	0
Pyrite	*Lower Kittanning*	0	1/16
Coal, cannel	*Lower Kittanning*	0	4
Shale, dark	*Lower Kittanning*	0	¼
Coal, bituminous, good	*Lower Kittanning*	2	1
Clay, light, plastic.			

150-69. N up road, SE¼NW¼ Sec. 13, E Killbuck Twp.

Shale, sandy, ferruginous	18	8
Coal blossom, *Lower Kittanning*	2	0
Clay, and covered	10	0
Shale, sandy; and covered	34	1
Shale, ferruginous	10	0
Limestone, *Putnam Hill,* altitude 1,100 feet	3	0
Clay shale	0	3
Coal, *Brookville*	1	2
Clay, and covered	5	0
Shale	10	0

151-74. In ravine and along road, SW¼NE¼ Sec. 18, SE Killbuck Twp.

Shale, sandstone; and covered		10	0
Limestone, blue, *Lower Mercer,* altitude 1,020 feet		2	0
Shale, carbonaceous, *Middle Mercer*		1	0
Clay, and covered		4	0
Sandstone, shaly		4	0
Sandstone, massive, coarse	*Massillon*	40	0
Sandstone, very massive; makes 30-foot falls	*Massillon*	30	0

152-75. SE up ravine to old quarry NE¼SE¼ Sec. 18, SE Killbuck Twp.

Limestone, old quarry, *Putnam Hill,* altitude 1,100 feet		3	0
Covered		9	0
Clay, *Brookville*		2	0
Clay shale, and covered		6	0
Shale, with sandy ore nodules		10	0
Sandstone, white, thin-bedded, ganister		28	0
Covered		2	0
Clay shale, gray		2	0
Clay shale, dark gray		2	0
Coal, cannel, fair	*Bedford*	0	11
Shale, dark, carbonaceous, coaly streaks	*Bedford*	1	0
Covered		5	0
Sandstone, cross-bedded		15	0

153-76. In road ditch and in field N of road, SE¼NE¼ Sec. 18, E Killbuck Twp.

	Ft.	In.
Limestone, *Putnam Hill*	3	0
Coal blossom, *Brookville*	1	0
Clay	1	0
Covered and clay	5	0
Sandstone, shaly to massive, (poorly exposed)	45	0
Coal, shaly, blossom *Bedford*	0	6
Clay, very sandy, almost ganister	5	0
Shale, sandy	4	0
Shale, sandstone; and covered	13	8
Limestone, blue, hard, fossiliferous, *Lower Mercer,* altitude 1,025 feet	5	0
Shale and covered	5	0

154-77. E and N up road NE¼SW¼ Sec. 23, SE Killbuck Twp.

	Ft.	In.
Shale	3	0
Limestone, *Putnam Hill,* altitude 1,090 feet	3	0
Coal blossom, *Brookville*	0	8
Clay, siliceous	5	0
Sandstone, clay-bonded	14	4
Covered	8	0
Shale, sandy	15	0
Clay shale, *Bedford* horizon?	8	0
Shale, and covered	9	0
Limestone, *Lower Mercer*	3	0

STRATIGRAPHIC SECTIONS FROM RICHLAND TOWNSHIP

157-268, 269. N up ravine and along road along line between NE¼ Sec. 5 and NW¼ Sec. 4, NE Richland Twp.

Pennsylvanian system

		Ft.	In.
Shale, sandy		5	0
Coal smut, *Tionesta*		0	2
Clay, light, siliceous		4	0
Shale, sandy		15	0
Shale, siliceous		14	10
Coal, weathered; not full thickness?	*Bedford,* altitude 1,210 feet	0	5
Clay shale, dark gray		0	7
Coal, weathered		1	1
Clay, light, plastic, siliceous		6	0
Shale and covered		5	3
Clay shale, ferruginous		15	0
Limestone, gray blue, hard, dense, fossiliferous, *Lower Mercer*		4	1
Clay, and covered		6	0
Covered		23	0
Sandstone, and covered	*Massillon*	36	0
Sandstone, irregularly bedded to massive		13	1
Sandstone, coarse, carbonaceous		1	8
Sandstone, massive		1	4

		Ft.	In.
Shale, dark gray, carbonaceous, rather hard	*Quakertown*, altitude 1,093 feet	0	8
Coal, hard, somewhat bony		1	1
Shale, hard, bone		0	2
Clay, very sandy; with some plant fossils		1	5
Sandstone, irregular, wavy bedding, micaceous, with 1-inch ore balls		1	4
Sandstone, irregular, coarse		0	11
Shale, siliceous		2	10
Covered		1	0
Shale, siliceous		5	0
Sandstone, irregular, coarse, somewhat massive		5	6
Covered and sandstone		17	0
Mississippian system			
Sandstone, thin-bedded, *Vinton*		20	0

158-359. Along the road in S½NE¼ Sec. 3, Richland Twp.

	Ft.	In.
Pennsylvanian system		
Shale, ferruginous	15	0
Limestone, dark blue, hard, dense, fossiliferous; somewhat thin-bedded and shaly near top, *Lower Mercer*, altitude 1,215 feet	2	0
Coal smut and covered, *Middle Mercer*	1	2
Clay and covered	4	0
Covered	6	6
Shale, sandy, micaceous	3	0
Shale, siliceous, with some ore balls	6	4
Shale, siliceous, with 2-inch to 3-inch sandstone layers	6	0
Shale, siliceous	3	4
Clay shale, slightly carbonaceous	1	8
Clay shale, gray	4	6
Clay and covered	1	6
Sandstone, massive, medium-grained, *Massillon*	61	0
Sandstone and covered	6	0
Mississippian system		
Sandstone, dark olive, thin-bedded, *Waverly*	20	0

159-360. At road fork in SE¼NW¼ Sec. 3, NW Richland Twp.

	Ft.	In.
Shale, sandy, ferruginous	6	0
Limestone, very dark blue, hard, slightly flinty, fossiliferous; (small blocks of black flint nearby but not seen in place); limestone broken up on outcrop, *Upper Mercer*, altitude 1,250 feet	3	8
Covered, and coal, evidently very shaly, *Bedford*	2	0
Clay and covered	6	0
Covered	3	10
Limestone, dark blue, hard, fossiliferous, not full thickness, *Lower Mercer*	1	6
Coal smut and covered	1	4
Clay, impure and ferruginous	4	6

160-361. W along road NW¼NW¼SW¼ Sec. 3, NW Richland Twp.

		Ft.	In.
Shale, siliceous		12	2
Covered		4	0
Flint, black, weathered, fossiliferous: (greater thickness indicated), *Upper Mercer*		1	2
Coal, weathered	*Bedford*	0	2
Clay shale, gray	*Bedford*	0	3½
Coal, fair, weathered	*Bedford*	0	5
Shale, coaly	*Bedford*	0	2½
Coal, fair, weathered	*Bedford*	1	2
Shale, coaly	*Bedford*	0	4
Clay, impure, sandy, micaceous		3	2
Shale, sandy, micaceous		12	11
Clay shale, ferruginous		3	0
Limestone, dark blue, argillaceous, dense, fossiliferous, *Lower Mercer,* altitude 1,250 feet		2	10

161-380. SE along road in SW¼NE¼ Sec. 4, NW Richland Twp.

Shale, weathered	6	0
Flint, black; a few loose pieces, *Upper Mercer*	0	6
Coal blossom, poorly exposed, *Bedford*	2	4
Clay, siliceous to sandy, with thin sandstone layers; part covered	6	8
Shale, sandy	6	0
Shale, sandy, somewhat ferruginous	16	8
Limestone, blue, dense, fossiliferous, *Lower Mercer*	1	6
Coal smut and covered, *Middle Mercer*	1	0
Clay, sandy, micaceous	8	4
Shale, siliceous, slightly micaceous, grading into white sandstone	22	6

162-379. Along road SE¼SE¼NW¼ Sec. 4, NW Richland Twp.

Clay shale, ferruginous	6	0
Limestone, dark blue, hard, slightly granular, fossiliferous, *Lower Mercer,* altitude 1,245 feet	2	11
Clay and covered	3	8
Coal blossom, *Flint Ridge*	1	3
Clay, gray, sandy, poor; and covered	9	2
Sandstone, white, micaceous, clay-bonded, thin-bedded to shaly	26	0

163-362. SE along highway from SW¼SE¼ Sec. 8 to lane entrance NW¼ NE¼ Sec. 13, W central Richland Twp.

Shale, siliceous, slightly ferruginous		6	0
Shale, dark blue, calcareous, very fossiliferous; (almost an argillaceous limestone)	*Upper Mercer,* altitude 1,220 feet	3	2
Limestone, dark blue, upper part argillaceous, lower more dense, fossiliferous, slightly flinty; loose blocks of flint on surface but none seen in place	*Upper Mercer,* altitude 1,220 feet	8	2

	Ft.	In.
Covered	3	8
Shale, black, hard, carbonaceous, *Bedford*	1	8
Clay, gray to gray brown, slightly carbonaceous	7	0
Sandstone, white, thin-bedded, clay-bonded	4	8
Sandstone, more irregular and thinner bedded than usual, *Massillon*	88	8
Clay shale; with layers of ore up to 4 inches thick, gray tan, weathered, somewhat nodular	3	0
Sandstone and covered	15	6
Clay and covered	1′	6
Sandstone and covered	13	0
Sandstone, ferruginous; pieces of ore; and covered, *Harrison*	3	0

164-364. E along road between SE¼NW¼ and NE¼SW¼ Sec. 13, ½ mi. E of railroad, Richland Twp.

	Ft.	In.
Sandstone, light	5	0
Coal, weathered, *Brookville*, altitude 1,250 feet	1	2
Sandstone, white; and covered	22	8
Limestone, dark blue, dense, fossiliferous; (scattered pieces black flint nearby but not seen in place), *Upper Mercer*	1	6
Coal smut and covered, *Bedford*	2	0
Clay, light, siliceous; poorly exposed	2	6
Sandstone, light, micaceous, clay-bonded	1	6
Shale, with lenses of ferruginous sandstone	6	10
Clay and covered	2	0

165-370, 371. Composite section made from section measured S from 1,195 crossroad, in SE¼ Sec. 18, and section E from same crossroad, to line between secs. 18 and 19, SW central Richland Twp.

		Ft.	In.
Shale, clayey, calcareous; contains ore nodules		9	8
Limestone, gray, dense, fossiliferous, *Putnam Hill*		3	4
Clay and covered, *Brookville*		5	0
Covered		11	0
Sandstone, light, shaly, clay-bonded		22	0
Shale, sandy, ferruginous; and covered		12	10
Clay shale, gray		1	6
Coal, weathered	*Bedford*	0	6
Clay shale, gray		1	2
Clay shale, dark		0	6
Coal, shaly, weathered		0	6
Clay, gray; not entire thickness		1	0
Covered		26	4
Crossroad, elevation 1,195 feet.			

166-373. N along road up to French Ridge from SE¼SW¼ Sec. 19 to NE¼SW¼ Sec. 19, Richland Twp.

	Ft.	In.
Shale	2	0
Limestone, gray, hard, dense, fossiliferous, weathered, platy, *Putnam Hill*, altitude 1,250 feet	4	8

		Ft.	In.
Clay, light, siliceous, slightly micaceous, plastic, (no coal showing)	*Brookville*	5	0
Clay, light gray, sandy		4	0
Shale, sandy; and covered		20	1
Flint, weathered, fossiliferous, loose blocks, *Upper Mercer*		0	6
Coal, fair		0	5
Clay shale	*Bedford*	0	3
Coal, weathered		0	9
Clay, light gray, plastic, fair		2	10
Shale, siliceous		19	2
Sandstone, thin-bedded; and covered		33	0

167-309. NE along road SE¼SE¼ Sec. 12, on French Ridge, Richland Twp.

	Ft.	In.
Limestone, brownish gray, hard, somewhat more granular than usual, *Putnam Hill*	2	6
Coal, clay; and covered, *Brookville,* altitude 1,260 feet	4	6
Shale, sandy	9	2
Shale, a trifle ferruginous	9	0
Coal, weathered, *Bedford*	1	7
Clay, dark gray, (not full thickness)	0	4

168-374. W along Holmes-Coshocton county-line road from SW Sec. 22 to SE Sec. 23, Richland Twp.

		Ft.	In.
Limestone, gray, loose pieces, platy, fossiliferous, dense, *Putnam Hill*		1	0
Clay, dark, carbonaceous, *Brookville*		4	6
Clay		3	0
Shale and covered		28	6
Flint, black, hard, shiny; not full thickness, *Upper Mercer*		0	10
Coal, weathered		0	8
Shale, siliceous	*Bedford*	0	1
Coal, weathered		0	10
Clay, light, plastic; some 1-inch sandstone layers		4	3
Covered		3	6
Sandstone, shaly to thin-bedded		15	4
Clay shale, weathered		0	6
Ore, weathered, irregular, nodular, *Lower Mercer*		1	0
Shale, drab, calcareous	*Lower Mercer* altitude 1,180 feet	1	11
Shale, dark blue to drab, calcareous, fossiliferous; apparently leached		5	3
Covered		14	1
Sandstone, massive, *Massillon*		22	0

169-340. Along a road NW¼SW¼ Sec. 24, SE Richland Twp.

	Ft.	In.
Clay shale, with ore balls, *Putnam Hill* horizon	5	6
Clay and covered, *Brookville*	3	0
Shale, sandy	10	10
Sandstone and covered	55	0

	Ft.	In.
Covered	22	0
Limestone, blue, hard, dense, to slightly granular, fossiliferous; not full thickness, *Lower Mercer,* altitude 1,140 feet	1	6
Clay and covered	3	0
Sandstone, massive; and covered	50	0

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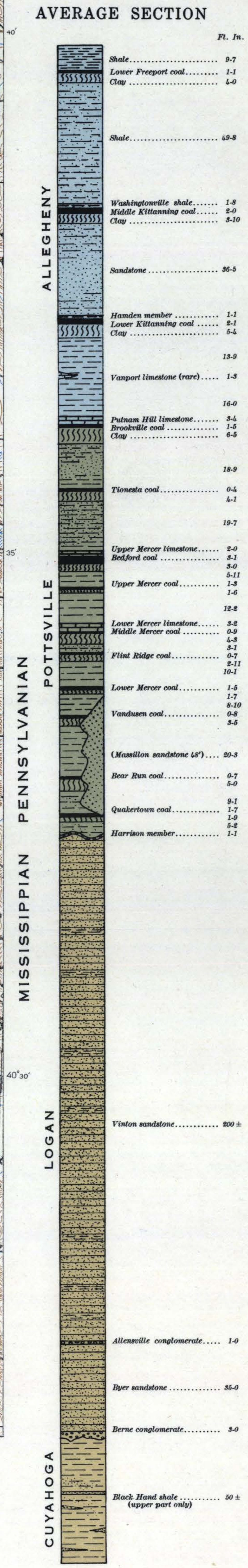

STATE OF OHIO
DEPARTMENT OF PUBLIC WORKS

GEOLOGICAL SURVEY OF OHIO
GEORGE W. WHITE, STATE GEOLOGIST

COLUMBUS
1947

GEOLOGIC MAP OF HOLMES COUNTY

By George W. White

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

EXPLANATION

PENNSYLVANIAN SYSTEM

- Pa — Allegheny formation
- Pp — Pottsville formation

MISSISSIPPIAN SYSTEM

- Ml — Logan formation (*includes upper part of Cuyahoga formation in northwestern part.*)
- —M— Outcrop of Middle Kittanning coal
- —L— Outcrop of Lower Kittanning coal